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THE QUEENSLAND JOURNAL OF AGRICULTURAL SCIENCE

Vol. 10. - - No. 1.
MARCH, 1953.

THE DETERMINATION OF OXALIC ACID IN PLANTS.

By K. W. MOIR, B.Sc., Analyst, Chemical Laboratory, Division of Plant Industry.

SUMMARY.

A titrimetric adaptation of Myers' modification of Bau's gravimetric method for determining water and acid extractable oxalate in plant material is described.

INTRODUCTION.

A gravimetric method for determining water and acid extractable oxalate in plant material was described by Bau (1919) and modified by Myers (1947). Myers specified a temperature of 70°C. for the extraction of water and acid extractable oxalate, and the precipitation of calcium oxalate from the boiling extract at a pH of approximately 5·2. In the original method of Bau, calcium oxalate is precipitated from a cold extract at a pH of approximately 4.0.

A titrimetric method involving the double precipitation of oxalate as calcium oxalate was described by Rimington and Steyn (1933). In this method, the plant is extracted with 0·25N. HCl at 100°C. for one hour. The oxalate is precipitated from the boiling extract at an indefinite pH on the acid side of neutrality. This method is inapplicable to some plant species, due to the presence of organic matter, which is reprecipitated with the calcium Queensland pasture plants (Mathams and Sutherland, 1952).

The method described in this paper was designed for ease in handling large numbers of samples in a survey of the oxalate content of some Queensland pasture plants (Mathams and Sutherland, 1952).

It is a titrimetric method adapted from Myers' modification of the gravimetric method of Bau. The extraction at 70°C. is combined with the precipitation of calcium oxalate from a cold solution at a pH of 4·0. Temperature control at 65°C. to 75°C. is important for the quantitative extraction of oxalate with a minimum extraction of interfering organic matter. The precipitation of the calcium oxalate from a cold aliquot of this extract at a pH of 4·0 gives consistently a relatively pure, crystalline precipitate of calcium oxalate. The nature of the calcium oxalate precipitated under these conditions favours its separation by centrifuging.

Bau allows for the solubility of calcium oxalate in water used for washing the precipitate by noting the volume of wash water used. Myers found that the solubility of calcium oxalate could be neglected when the oxalate was determined by his modified method. The greater solubility of calcium oxalate in Bau's method could be due to the fine nature of the calcium oxalate crystals when oxalate is precipitated from a cold solution.

In the method described below, an alcohol ammonia mixture, in which calcium oxalate is for practical purposes completely insoluble, is used for washing the precipitate. The use of this reagent has the further advantage that its removal by heating prior to the titration by permanganate renders traces of impurity insoluble in the acid used for the titration.

REAGENTS.

(1) Approximately 0·25N. HCl made by diluting concentrated acid (S.G. 1·16) 40 times.

(2) Precipitating reagent. (To facilitate weighing, calcium acetate is substituted for calcium chloride in the "Kalkessig" reagent described by Bau).

Solution A. 96·5 g. anhydrous sodium acetate is dissolved by warming in distilled water and made to 250 ml.

Solution B. 18 g. anhydrous calcium acetate is dissolved in 250 ml. of 50 per cent. aqueous acetic acid.

Solution A is mixed with Solution B and filtered after standing in a refrigerator for 48 hours. The reagent is filtered if necessary before use. It keeps indefinitely when stored in a refrigerator.

(3) Calcium oxalate washing reagent: 240 ml. of 96 per cent. alcohol and 125 ml. of concentrated ammonia solution (S.G. 0·92) are made to 500 ml. with distilled water.

(4) Approximately 2N. H_2SO_4 made by diluting concentrated acid (S.G. 1·84) 18 times.

(5) 0·02N. potassium permanganate prepared before use from 0·1N. stock solution.

METHOD.

1. Total Oxalate.

The plant is dried sufficiently at 100°C. to permit its being finely ground in a laboratory mill. A moisture determination is made on the milled material.

The sample is weighed out to 2·50 g. and transferred to a 250 ml. volumetric flask. Approximately 220 ml. of 0·25N. HCl is added and the flask heated in a water bath at 70°C. for one hour. When cool, 0·25N. HCl is added to make 250 ml. and the contents thoroughly mixed. Approximately 10 ml. is filtered through an 11 cm. Whatman No. 2 filter paper and this

portion is rejected. A further 10 ml. is filtered through the same filter paper and 5 ml. is pipetted into a 10 ml. centrifuge tube. This is cooled to about 10°C. and 1 ml. of the precipitating reagent added with stirring. The stirring rod is washed with a few drops of water. The oxalate is precipitated overnight in a refrigerator and is then centrifuged for 5 minutes at an R.C.F. value of 1,800 (approx. 2,700 r.p.m.). The supernatant liquid is carefully poured off by inclining the tube and the drop collecting on the rim is removed with filter paper. The precipitate is dissolved in 5 ml. of 0·25N. HCl and precipitated and separated as before. To this, 5 ml. of washing reagent is added down the sides of the tube, stirred and the stirring rod washed with water. After centrifuging and separating, the tube is heated in an oven at 100°C. for 30 minutes. The dried precipitate is dissolved in 5 ml. of 2N. H_2SO_4, heated in a beaker of boiling water and titrated with 0·02N. $KMnO_4$ from a burette graduated to 0·02 ml. divisions. The burette should be read to the nearest 0.01 ml.

A glass rod bent at right angles, to serve as a stirring rod, facilitates the titration. If the titration is likely to exceed 3 ml. the contents should be washed into a small flask.

Calculation: Corrected for moisture, the result is expressed as per cent. anhydrous oxalic acid.

Titration in ml. $\times$ 1·801 = per cent. anhydrous oxalic acid.

2. Water Soluble Oxalate.

In a 250 ml. volumetric flask 2·50 g. of the milled plant material is extracted with 220 ml. of distilled water at 70°C. for one hour, made to 250 ml., and 5 ml. of the filtered extract pipetted into a 10 ml. centrifuge tube. Then 0·12 ml. of concentrated HCl is added and the contents mixed, then heated at 70°C. for 20 minutes in a water bath. If a precipitate forms, this is removed by centrifuging and the supernatant liquid poured into another centrifuge tube. By centrifuging again for a few seconds with about 0·2 ml. of water, the remaining drop may be removed almost completely. The oxalate is precipitated and titrated as for total oxalate and similarly calculated.

DISCUSSION.

The accuracy of the above methods has been tested with standard oxalate solutions and with recoveries on plants containing oxalate and on plants containing no oxalate. The analyses agreed with the theoretical value within $\pm$ 0·01 ml. titration, equivalent to 0·02 per cent. oxalic acid in the plant as analysed. This applies to concentrations of oxalic acid up to 5 per cent. The percentage error does not exceed 1 per cent. for concentrations higher than 5 per cent.

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THE WOODINESS VIRUS OF THE PASSION VINE (*Passiflora edulis* Sims).

By T. McKNIGHT, M.Sc., Pathologist, Science Branch, Division of Plant Industry.

SUMMARY.

1. *Studies on the epiphytology, symptomatology and transmissibility of the woodiness virus are reported.*

2. *Initial infections of new plantings are commonly highest in portions adjacent to a diseased source. In unpruned plantations there is no significant difference between the infection rate near a previously healthy vine and that near a diseased vine. Though there is a continuous reservoir of virus infection in the concentrated horticultural districts of south-eastern Queensland, local isolation within the farm may ensure freedom from the virus for 10 months after planting vines.*

3. *Greenhouse and field studies have shown 13 distinct symptoms to be associated with the virus. These are described. A seasonal variation in the expression of individual types of symptoms has been observed.*

4. *Apart from occasional high populations of a few species, the passion vine supports a relatively small insect fauna. The known aphid vectors of the woodiness virus do not colonise the passion vine by choice but breed on weeds and other plants in and around the plantation.*

5. *The virus is readily transmitted in the greenhouse (at mean maximum temperatures from 72.2°F. to 106.4°F.) by mechanical means, by the leaf-grafting technique, or by the insertion of a rectangular piece of leaf under the cambium of the stem.*

6. *The time taken for the expression of the first symptom (the characteristic terminal reaction) in infected seedlings is governed by temperature. It varies from 7 days at 98.1°F. to 24.6 days at 73.2°F.–79.5°F.*

7. *The reactions of other species of Passiflora to infection with the woodiness virus are described.*

8. *The virus can be transmitted readily from an infected vine to a healthy vine by cutting with secateurs.*

9. *It has been demonstrated by selective mechanical and leaf graft transmissions in the greenhouse that the relative concentrations of different components of the virus can be altered. The fern leaf symptom was segregated*

from the virus mixture and maintained free from the typical mottle symptom. It was then shown that the typical mottle is responsible for the production of the characteristic terminal reaction.

10. *It is postulated that the woodiness virus as it occurs in Australia exists as a complex of strains and is not a single entity, as previously thought.*

HISTORY OF THE WOODINESS VIRUS.

According to Cobb (1901), the woodiness virus of passion fruit was known in New South Wales at least as early as 1891. He reported that the disease appeared to a serious extent about 1897, but that its serious effects were restricted to the County of Cumberland. The epiphytotic incidence of the virus within plantations reported by Cobb over 50 years ago is of considerable interest—"Whole vineyards may suffer so severely that hardly a vine escapes, and most of the vineyards in a given locality may be afflicted . . ."

Over the intervening years the virus has spread rapidly and it is now the greatest disease menace of passion vines in the eastern States of Australia. The decline in productivity in New South Wales from 0·4 bushels per vine in 1913 to 0·2 bushels in 1937 was mainly attributable to the disease (Noble and Noble, 1939). Simmonds (1938) rated woodiness as the most important disease of passion vines in Queensland and reported that it was only since 1931 that the disease had assumed serious proportions in the State. Since that time it has become of universal occurrence in the coastal and mountain plantations of south-eastern Queensland.

Elsewhere, the disease has been recorded in Kenya (McDonald, 1937), in South Africa (Storey, 1940), and, probably, in England (Bewley, 1923), and in Sumatra (Palm, 1922).

Three names have been assigned to this disease by various workers—"woodiness," "bullet" and "mosaic." The self-explanatory "woodiness," referring to the economically important symptom of the woody, misshapen fruit, proposed by Cobb in 1901, was the first name suggested and would appear to be the most suitable.

EPIPHYTOLOGY.

In south-eastern Queensland the passion vine is cultivated on a large percentage of small-crop and fruit farms, both in the coastal areas and on the coastal range country. In the coastal areas passion vines are grown mainly in association with bananas, pineapples, strawberries, papaws, tomatoes, cabbages and cauliflowers. On the coastal range country they are grown together with bananas and pineapples.

Twenty years ago plantations of 10 acres and over were relatively common, but today the areas are small, varying from half an acre to six acres on individual farms, but most commonly about one acre. The smaller areas now farmed to this lucrative crop are the direct result of a persistent complex of diseases, of which the woodiness virus is the most consistently damaging.

The other diseases of the complex are Fusarium wilt, brown spot (*Alternaria passiflorae* Simmonds) and Septoria spot (*Septoria passiflorae* Louw). The high number of plantings still persisted with is the result of the appeal of the high return per acre obtainable from the harvesting of one or two crops of fruit before the diseases render the vines totally unproductive.

The majority of growers, then, while reluctant to neglect an opportunity to obtain a good cash return from a small area of vines over a short period, have a philosophical outlook on the future of the planting, and the small plantation receives scant attention from the point of view of disease control. When the existing planting becomes unproductive, a new area is planted, often while the old diseased vines are still in position. Further, these diseased plants frequently remain in position over the whole of the period of the establishment of the seedbed, the planting out, and the early growth of the new vines.

It was observed over the period of these investigations that a high percentage of infection occurred early in the life of new plantings adjacent to old, diseased areas. Infections as high as 100% were recorded in 9- and 10-month-old plantations in 1946 and 1947 when such plantings were adjacent to older diseased areas.

In Fig. 1 the incidence of the virus in a 9-month-old plantation approximately 8 yards from the closest row of a 2-year-old vineyard is plotted. An examination of the position of infected vines in this plantation suggests the spread of the virus from the neighbouring source into the new planting.

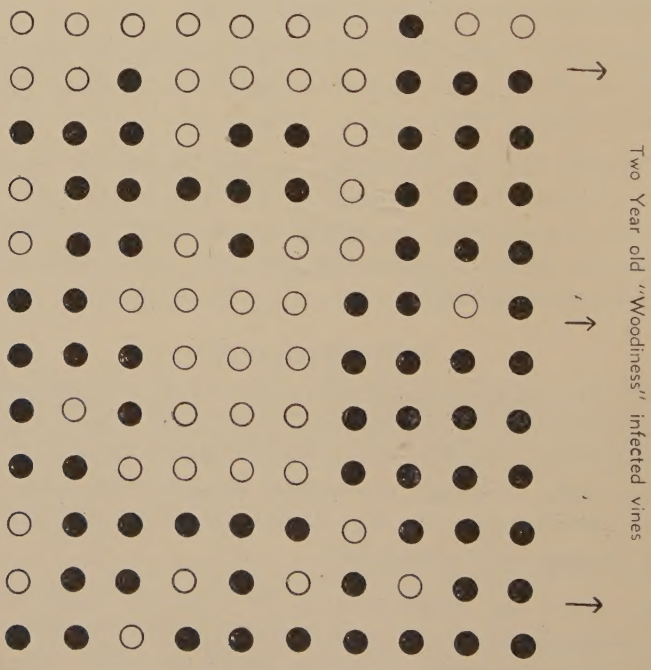

Fig. 1.—Incidence of "Woodiness" in 9-month-old vines. (Redland Bay Road, 3.9.46.)

Three more or less typical farms in the Redlands district (near Brisbane) were selected for detailed observations on the incidents of the virus within plantations. The data have been statistically examined, tests made for departure of the distribution of the infected vines from randomness, and the association of later infections with earlier infections determined.

Plantation A.

The incidence of the virus was plotted on September 2, 1946, when the vines were nine months old, and subsequently in October and November when the typical foliage mottle and the malformed fruit symptoms were well expressed. With the reappearance of the foliage mottle in April 1947, the occurrence of the virus was plotted then and again at the beginning of June and towards the end of August, by which time all vines (then 17 months old) in the planting were infected. There were uncultivated areas on the northern and eastern sides of this vineyard and a plantation of bananas on the western side; the area was bounded on the south by a plantation completely infected with woodiness when plotting commenced.

At the time of the first plotting the initial infections were not randomly distributed, the percentage infected being higher in the southernmost three rows (i.e., in the rows nearest the disease source), mainly due to the higher percentage infected in the lower south-western area. Fresh infections to November 27, 1946 showed no significant departures from randomness, but

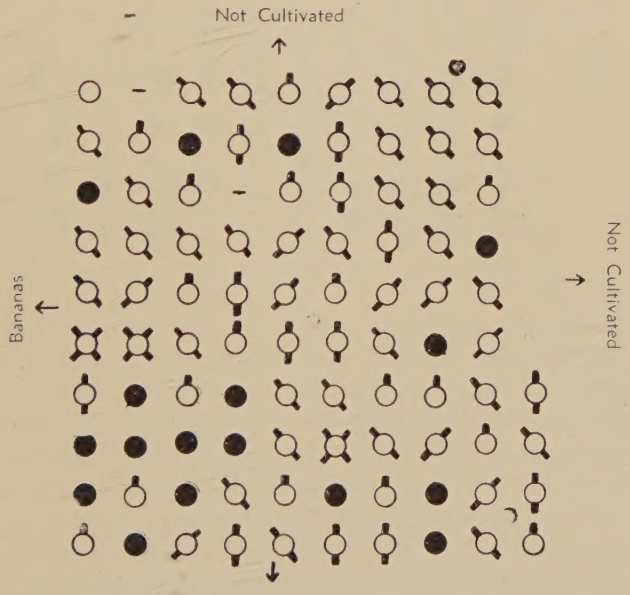

Fig. 2.—Field Plan, Plantation A, Cleveland.

total infections to that date showed some indication of a departure from randomness, the percentage infected increasing from the northern end of the planting to the southern end (i.e., the percentage infected was highest in the areas closest to the diseased source).

The difference between the infection rates near a healthy vine and near a previously infected vine was not significant.

The disease incidence map of this plantation is shown in Fig. 2.

Plantation B.

In this plantation the incidence of the virus was plotted in September and October of 1946 and subsequently in July 1947, by which time all vines were infected. This planting was bounded on the western and eastern sides by an uncultivated area and a banana plantation, respectively; on the south-eastern side five chains away was a source of the virus in 2-year-old infected plants; and on the northern end a few yards away was an infected planting of 2-year-old and 9-month-old vines.

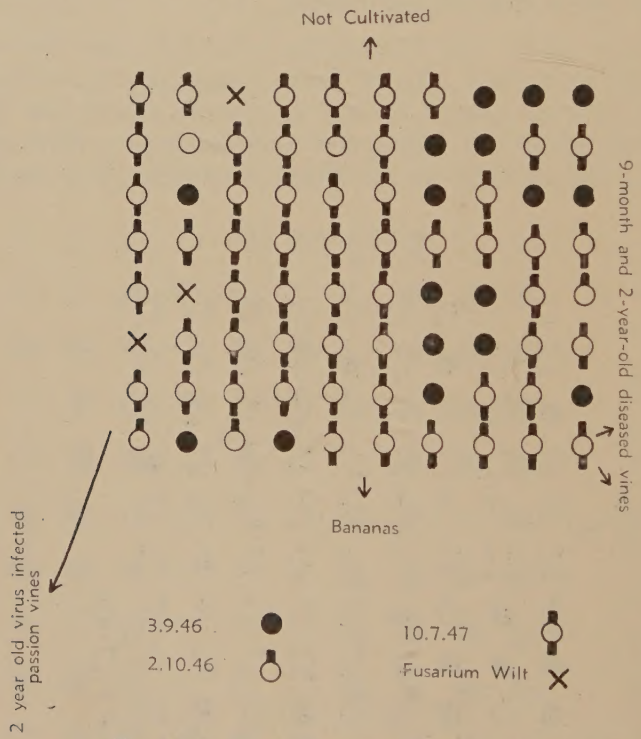

Fig. 3.—Field Plan, Plantation B. Pinklands.

The incidence of the virus in this plantation is shown in Fig. 3.

Analysis of the data from this plot showed that there was some indication of a progressive increase in the percentage infected from the southern to the northern side of the planting (i.e., the percentage infected appeared to be higher in the vines closest to the nearest diseased source). No test of neighbour infection was carried out in this planting.

Plantation C.

In this plantation the virus incidence was plotted in September, October and November, 1946, and subsequently in June 1947, at which time every vine was infected.

This planting was bounded by an area of pineapples, a banana plantation, an uncultivated area, and, on the north-eastern side, a 2-year-old passion vine plantation infected with woodiness (Fig. 4).

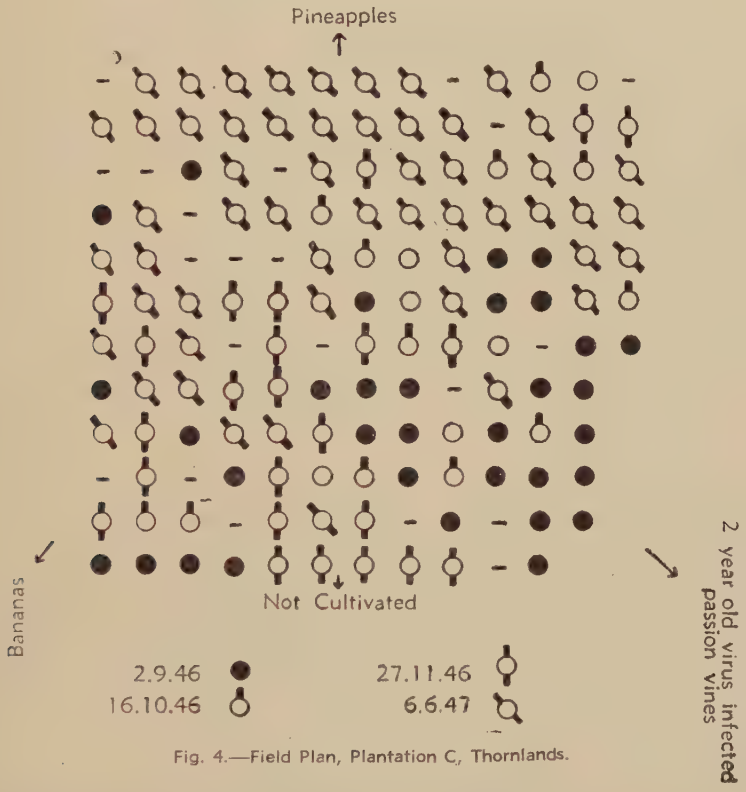

Fig. 4.—Field Plan, Plantation C, Thornlands.

Examination of the data from this plantation showed that the initial infections were not randomly distributed. The percentage infected increased progressively from the western to the eastern side of the planting; the western half showed a significantly lower percentage infected than the eastern half. The percentage infected was higher in the north-eastern quarter of the plot than in the other quarters (i.e., the vines nearest to the source of infected vines showed a higher proportion of infections). Fresh infections up to November 27, 1946, and total infections to the same date showed a marked increase in the proportion infected from the western side to the eastern side of the plantation.

The vines not diseased on September 2, 1946, were subdivided into two classes—those near healthy vines and those near an infected vine. Each of these classes was later subdivided into two classes—healthy and infected at

27/11/46. The classifications were carried out along the rows, the end plants being classified according to the nature of the adjacent vine in the same row. The X^2 test showed that the difference between the infection rates near a previously healthy vine and near a previously infected vine was not significant.

The vines in these examples were not mechanically pruned, and mechanical transmission by this method can be ignored. However, the extent of seedbed infection prior to planting out cannot be overlooked, or in these examples, actually assessed.

Table 1.

Woodiness in 10-month-old Passion Vines.

Grower.	Percentage Infection.	Presence or Absence of Older Infected Vines on Property.	Other Crops Growing in Immediate Vicinity of Young Vines over 10-month Period.
No. 1	100	Present	Passion vines ; lettuce.
No. 2	61	Present	Passion vines
No. 3	23	Present	Passion vines ; bananas ; pineapples
No. 4	21	Present	Passion vines ; bananas
No. 5	17	Present	Passion vines
No. 6	0	Absent	Bananas ; cabbages ; tomatoes
No. 7	0	Absent	Tomatoes
No. 8	0	Absent	Bananas ; custard apples ; papaws tomatoes

While there is a continuous reservoir of virus infection present in the concentrated horticultural districts of coastal south-eastern Queensland, it has been determined that local isolation within a farm will give early freedom from infection in a new planting. This freedom from the virus may persist over 10 months. An examination of eight 10-month-old plantations in the Thornlands district was made in September 1946; the results are shown in Table 1. Growers 5–8 used a common source of seed—from No. 5. The extent of infection after 10 months is of particular interest, as it would appear to be associated with the presence or absence of older infected vines on the property.

SYMPTOMATOLOGY.

There is great variation in the symptoms produced by the woodiness virus, and in addition, there is seasonal variation in the expression of individual types of symptoms. The complete series of symptoms produced has not previously been described.

Symptoms.

As the result of field and greenhouse studies on the virus, the following 13 types of symptoms are now recorded:—Malformed fruit; typical foliage mottle; yellow spot mottle; terminal bunchiness; translucent areas; foliage ring spot; fruit ring spot; stippled fruit; fern leaves; tip chlorosis; stem mottle; vein hypertrophy; seedling terminal reaction. The first 11 symptoms occur in the field. The last two have been observed only in the greenhouse.

Table 2.

FIELD SYMPTOM TYPES AND THEIR SEASONAL OCCURRENCE IN SOUTH-EASTERN QUEENSLAND

Type of Symptom.	Summer.		Autumn.		Winter.				Spring.		Summer.	
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.
Translucent Areas in Terminal Leaves	+	+	+	+	+	+	+	+	+	+	+	+
Terminal Bunchiness	−	+	+	+	+	+	+	+	+	+	+	+
Typical Foliage Mottle	−	−	+	+	+	+	+	+	+	+	+	−
Yellow Spot Mottle	−	−	−	+	+	+	+	+	+	+	+	+
Foliage Ring Spot	−	−	−	−	+	+	+	+	+	+	+	..
Stippled Fruit	−	−	−	−	−	+	+	+	+	+	+	..
Malformed Fruit	−	−	−	−	−	+	+	+	+	+	+	..
Fruit Ring Spot	−	−	−	−	−	−	−	+	+	+	+	+
Tip Chlorosis	−	−	−	−	−	−	−	+	+	+	−	−
Fern Leaves	−	−	−	−	−	−	−	−	+	+	+	+
Stem Mottle	−	−	−	−	−	−	−	−	+	+	−	−

The seasonal occurrence of the symptoms in the field is shown in Table 2. This summary is based on numerous observations carried out in south-eastern Queensland during the years 1946, 1947 and 1948.

1. Malformed Fruit.

This (Fig. 5) is the economically important symptom, consisting of more or less grossly misshapen fruit (with abnormal thickening and hardening of the tissues of the pericarp and reduced pulp cavity), which are produced on infected vines from June to November in south-eastern Queensland. Outside this period the fruit on infected vines are not grossly misshapen, but they are smaller in size than healthy fruit, are not perfect in shape, and have a thicker pericarp.

Woody fruit are detectable by their uneven shape when the fruit measure only $\frac{1}{4}$ in. to $\frac{1}{2}$ in. along their longest dimension. A mottle on the calyx accompanies the fruit symptoms.

2. Typical Foliage Mottle.

This is a broad bullate mottle with the dark-green areas localized on the raised or blistered portions of the leaf (Fig. 6). The blisters are raised from the top surface of the leaf. The leaf colour between the dark-green, raised areas is yellow-green. The leaves present a puckered apparance and are frequently misshapen. This mottle can be readily detected from March until November, but its expression is most marked during the winter and spring months. A fleeting mottle can be seen in the summer months just behind the terminals.

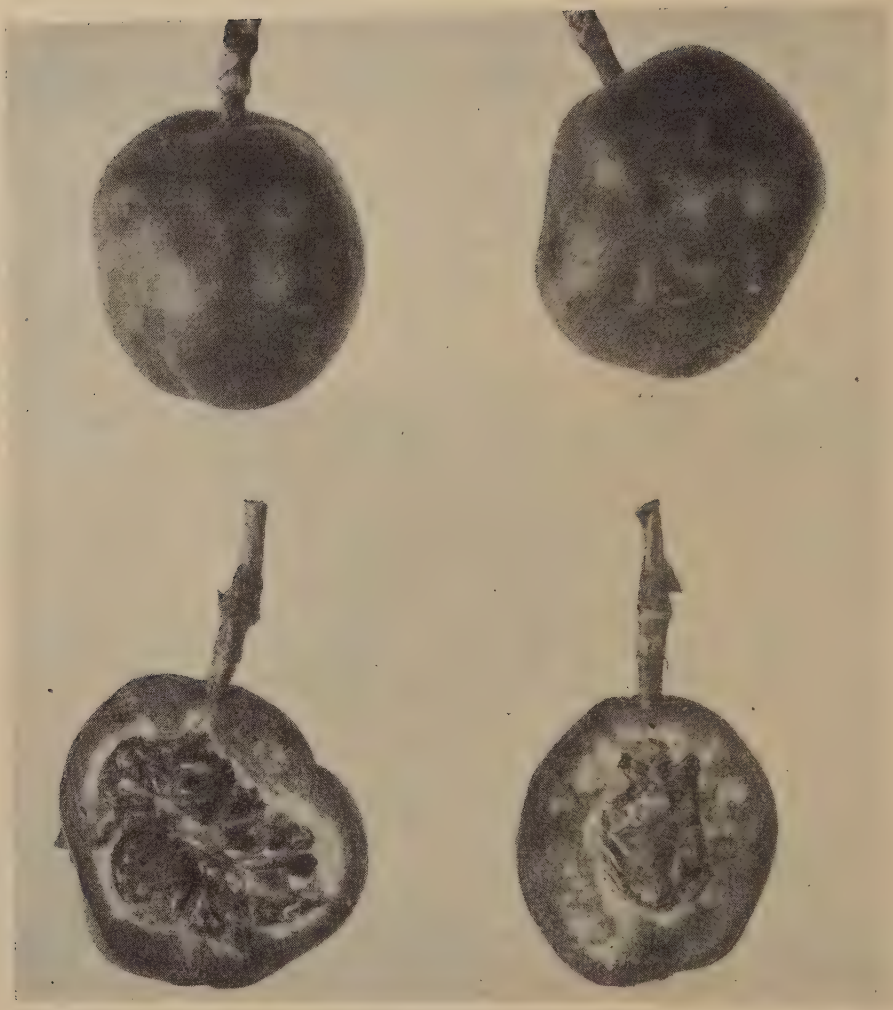

Fig. 5.
Deformed Fruit with Thickened Pericarp and Reduced Pulp Cavity.

The yellow spot mottle may be associated with the typical mottle. Occasionally a leaf may be seen with both of these mottles present but with each distinctly confined to definite areas of the leaf.

3. Yellow Spot Mottle.

This mottle is produced by numerous small yellow spots on the leaf (Figs. 7 and 8). Occasionally the spots may be few in number, discrete, and occur unmixed with any other leaf mottle. The yellow spots are generally circular in shape, but when large are irregular in outline and occasionally have a necrotic centre. This mottle occurs on the vines from April to November. It is commonly associated with the typical mottle and may also occur on fern leaves. It is best expressed on older leaves.

Fig. 6.

Typical Bullate Foliage Mottle. Normal plant at right.

4. Terminal Bunchiness.

This symptom is a lack of growth at the terminal accompanied by a bunchiness of harsh-textured terminal leaves. It may be detected on systemically infected vines in any month of the year but is best expressed in winter, when the terminal leaves are markedly downcurled along the axis of the main vine.

5. Translucent Areas.

Infected vines show a vein clearing in the terminal leaves accompanied by translucent or cleared areas. This symptom may be detected at any time of the year.

6. Foliage Ring Spot.

This is a relatively rare symptom. Ring spots are associated with the yellow spot mottle (Fig. 8) and are caused, apparently, by the rearrangement of the yellow spot mottle into rings. Tissue bounded by the rings is green and does not become necrotic.

7. Fruit Ring Spot.

Ring spots (Fig. 9) may occur on normal fruit or on fruit that are misshapen and have hardened and thickened pericarps. They may occur as circular, green, discrete ring spots with a purple centre, up to $\frac{3}{4}$ cm. in

Fig. 7.
Yellow Spot Mottle.

diameter, and as small as 3 mm. in diameter. They may fuse during development to give large, irregularly shaped outlines. They can occur on all portions of the fruit but may be confined to one half of it. Frequently their occurrence is more intense on one side of the fruit.

As the fruit ripen and shrivel the ring spots gradually become obscure. When ring spots occur in fruit which are still green, their centre remains a "greasy green" as the fruit ripens in place of the purple in a riper fruit. In this case, as the fruit ripens the ring spots again become obscure and the final result is the presence of a number of larger or smaller greasy-green dots or spots on the normal green of the fruit. Such fruit may ripen normally.

8. Stippled Fruit.

Markings occur on the fruit in the form of an irregular dotted and stippled pattern below the epidermis. On green fruit the pattern appears, in contrast, as a grey colour. When they are small, the swellings may be roughly circular but they are generally fused to give an irregular pattern.

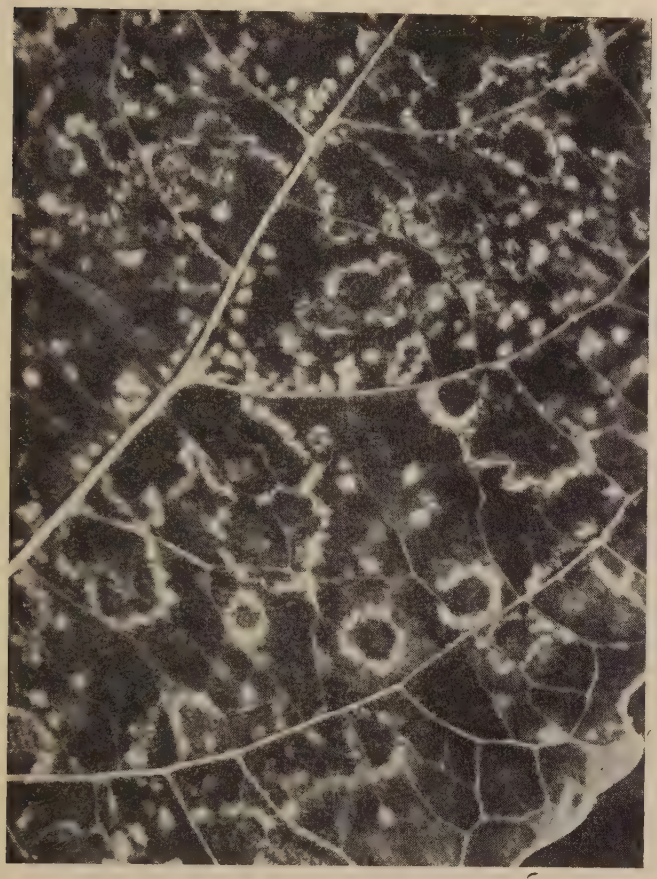

Fig. 8.
Foliage Ring Spot Accompanied by Yellow Spot Mottle.

9. Fern Leaves.

Fern leaves are distorted leaves, the individual leaf lobes being filiform and having irregular or serrated margins (Figs. 10–12). In the field and in the greenhouse the typical woodiness mottle is not found associated with fern leaves, but yellow spot mottle may be associated with this symptom (Fig. 11). In the field, fern leaves are produced over the period September to December.

10. Tip Chlorosis.

The terminal leaves are chlorotic, with a trace of green vein banding. Associated with the tip chlorosis is the stem mottle described below. Small, brown, necrotic, slightly depressed lesions appear on the stem near the terminal, and the terminal leaves and tendrils die back. Tip chlorosis is present in the field during the months of August, September and October.

11. Stem Mottle.

A light-green mottle may occur on the stems and petioles of infected plants, and is prominent in the field in September and October. The stem mottle may be produced in the greenhouse in the winter months.

Fig. 9.
Fruit Ring Spot.

Fig. 10.
Fern Leaf Type.

Fig. 11.
Fern Leaf Accompanied by Yellow Spot Mottle.

12. Vein Hypertrophy.

This consists of a raised main vein, which commonly pursues a zigzag path. The symptom is not infrequently encountered in the greenhouse, but has not been observed in the field.

13. Seedling Terminal Reaction.

This is the first symptom shown in the greenhou e by seedling passion vines after inoculation with the woodiness virus. The terminal reaction consists of a marked downcurling of the first unfolded terminal leaflet, followed by spiral twisting, and the cupping-under of the leaflet edges (Fig. 13). Vein

Fig. 12.

Extreme Forms of Fern Leaves Produced in the Greenhouse.
Normal leaf at top left.

clearing occurs and translucent areas appear. All these symptoms may appear also in the second unfolded leaflet, while in the third unfolded leaflet marginal waving is commonly the only symptom present.

SUMMER SYMPTOMS OF WOODINESS IN THE FIELD.

Even over the period of least expression of the virus during high summer temperatures, infected vines may be detected in the field by the presence of the following symptoms. Growth is less than in a healthy vine; it may actually cease in some laterals, and a bunchiness of the terminal leaves occur. The texture of the older leaves is harsh, and while fruit

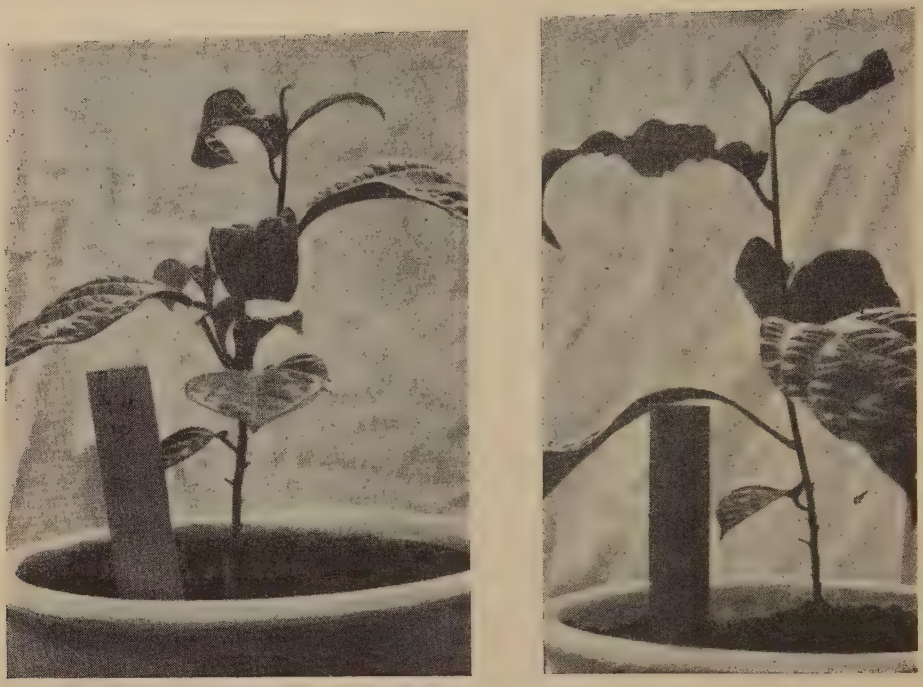

Fig. 13.

Seedling Terminal Reactions. Left, downcurling of first and second unfolded leaflets along axis of main vein. Right, spiral twisting of first unfolded leaflet. Both 12 days after mechanical inoculation.

produced at this time are not obviously deformed they are not perfect in shape and tend to be thickened in the pericarp. A fleeting mottle may be detected in the leaves just behind the terminal leaves. Translucent areas occur in the terminal leaves; they are shown by a clearing of the normal light-green colour in the vicinity of the veins.

Symptoms again become well expressed in March with the appearance of the prominent typical foliage mottle.

INSECT POPULATIONS OF THE PASSION VINE.

Noble and Noble (1939) demonstrated transmission of the virus by *Myzus persicae* (Sulz.) and by *Macrosiphum gei* Koch, together with two unnamed species of aphids. Magee (1948) showed that *Aphis gossypii* Glov. is also a vector.

It was observed early in these investigations that, apart from occasional high populations involving a few species, the passion vine normally supports very few insects. In order to determine the extent of the insect populations on passion vines in Queensland, sampling was conducted at fortnightly intervals over a period of 13 months on four plantations located at Victoria Point, Cleveland and Ormiston. Net sweeping of the passion vine foliage, apart from rendering difficult the recovery of mites and thrips, was found

relatively ineffective, and a sampling method was adopted, taking 20 flowers, 20 terminals, and 20 leaves at random into separate containers on each of the four plantations. In the laboratory, ether was placed in the canisters and the leaves and flowers were shaken over white paper and then brushed with a camel-hair brush. It was then found necessary to examine the leaves and flowers with a binocular microscope and to remove the mites and small insects with a camel-hair brush.

The results obtained are shown in Tables 3–6.

Aphids were found present from March to September but their population on the vines throughout the 13 months was very low. Species detected were *Aphis gossypii, Macrosiphum gei* and *Aphis rumicis* L.

Table 3.

INCIDENCE OF INSECTS ON THE PASSION VINE—PLANTATION 1, ORMISTON.

Date.	*Thrips tabaci.*	*Thrips imaginis.*	*Taeniothrips kellyanus.*	*Thrips* spp.	*Haplothrips froggatti.*	*Aphis gossypii.*	*Macrosiphum gei.*	*Aphis rumicis.*	*Aphis* spp.	*Acarina.*	Miscellaneous.
21–8–46	40	19	..	..	..	2	2	..	..	..	1 Phalacridae
10–9–46	84	26	1	1	..	..	1	..	..	..	
2–10–46	15	9	..	..	..	..	..	..	..	..	2 Coccinellidae
16–10–46	..	..	..	2	..	..	..	..	..	..	3 Entomobryidae
30–10–46	66	..	..	..	..	..	..	..	..	..	
13–11–46	41	..	..	..	..	..	..	..	..	..	
11–12–46	4	..	..	..	..	..	..	..	..	..	
8–1–47	6	..	..	..	..	..	..	..	..	..	
5–2–47	..	..	..	..	..	..	..	..	..	..	
19–2–47	..	..	..	..	..	..	..	..	..	..	1 *Siphanta acuta*
13–3–47	1	..	..	..	..	..	..	..	..	5	Eggs of *Caedicia*
27–3–47	..	..	..	..	..	6	..	..	..	12	2 *Pheidole megacephala*; 2 Psocoptera; 2 Pseudococcidae
9–4–47	..	..	..	..	..	..	..	..	1	5	2 Psocoptera; 1 Chalcidoidea; 1 Coccidae
23–4–47	..	..	2	4	..	..	..	..	..	18	3 Psyllidae; 2 Psocoptera
7–5–47	..	..	..	1	..	1	..	..	1	8	2 Miridae; 1 Coccidae
22–5–47	1	..	..	..	..	..	..	..	..	2	1 Chalcidoidea; 1 Psocoptera
4–6–47	7	..	..	..	..	..	..	..	..	..	2 Psocidae; 3 Formicidae
19–6–47	..	..	..	..	..	..	..	..	..	..	2 Psocidae; 2 *Neophysopus* sp.
4–7–47	1	..	..	..	..	..	..	2	..	1	1 Delphacidae
23–7–47	9	..	..	..	..	..	..	..	2	..	
6–8–47	4	..	..	2	..	..	..	..	..	..	2 Hemiptera
25–8–47	79	..	..	9	..	..	..	..	..	1	2 Psyllidae; 2 *Neophysopus* sp.; 2 Coleoptera; 5 Homoptera
12–9–47	99	..	3	..	..	..	..	..	..	..	2 Hemiptera
24–9–47	71	..	..	..	2	..	..	..	..	11	Scores of Lepidopterous larvae; 3 *Corticaria australis*
Total ..	528	54	6	19	2	9	3	2	4	63	

A number of nymphal aphids were found to be present, indicating that some breeding was, in fact, occurring on the vines. However, from the numbers found it would appear unlikely that the aphids breeding on the vines were the major agents in the extensive infections with the virus recorded in vineyards over the period of the investigations.

Apart from the regular samplings in these four plantations, observations were made for aphid vectors elsewhere. *Myzus persicae, Aphis rumicis* and *A. gossypii* were found present on young passion vines in the Redland Bay and Victoria Point areas in April and May of 1946. In June 1946, small

Table 4.

INCIDENCE OF INSECTS ON THE PASSION VINE—PLANTATION 2, REDLAND BAY ROAD, CLEVELAND.

Date.	*Thrips tabaci.*	*Thrips imaginis.*	*Taeniothrips kellyanus.*	*Thrips* spp.	*Haplothrips froggatti.*	*Aphis gossypii.*	*Macrosiphum* sp.	*Aphis rumicis.*	*Aphis* spp.	*Acarina.*	Miscellaneous.
2–9–46	52	..	..	..	..	..	..	..	..	..	2 *Rhizobius* spp.
10–9–46	63	19	..	..	..	..	..	..	7	..	
2–10–46	14	8	..	..	..	..	..	..	..	..	4 Nitidulidae; 2 Chrysomelidae; 2 *Pheidole megacephala*
16–10–46	14	6	..	..	..	..	..	..	..	..	2 Lathridiidae
30–10–46	..	..	..	..	..	..	..	..	..	..	
13–11–46	68	..	..	..	..	..	..	..	..	..	1 Nitidulidae
27–11–46	2	..	..	..	..	..	..	..	..	..	
11–12–46	..	..	..	..	..	..	..	..	..	..	
8–1–47	7	..	..	1	..	..	..	..	..	..	1 *Pheidole megacephala*; 1 Coccid
5–2–47	2	..	..	..	..	..	..	..	..	..	1 *Pristhesancus papuensis*; 1 *Coccinella transversalis*
19–2–47	..	..	..	..	..	..	..	..	..	..	
27–3–47	..	..	..	..	..	..	..	..	..	..	
9–4–47	..	..	..	..	..	..	..	..	1	6	
23–4–47	..	..	..	..	..	..	..	..	2	1	1 Psocoptera
7–5–47	..	..	..	1	..	..	..	..	1	7	
22–5–47	..	..	..	..	..	..	..	..	1	6	
4–6–47	..	..	..	1	..	..	..	5	..	..	2 *Neophysopus* sp.; 2 Coleoptera
19–6–47	..	..	..	..	..	..	..	..	..	..	3 Lepidopterous larvae; 2 *Neophysopus* sp.
4–7–47	..	..	..	2	..	..	..	1	..	..	2 *Agonoscelis rutila*
23–7–47	..	..	..	..	..	..	..	..	..	2	
6–8–47	..	..	..	2	..	..	..	..	..	..	8 *Neophysopus* sp.
25–8–47	10	..	..	..	..	2	..	..	..	..	2 *Neophysopus* sp.; 2 Psocoptera
12–9–47	72	..	4	4	..	..	..	..	..	..	4 *Nezara viridula*; 2 *Corticaria australis*
24–9–47	14	..	..	..	..	..	..	..	..	..	
Total ..	318	33	4	11	..	2	..	6	12	22	

Table 5.

INCIDENCE OF INSECTS ON THE PASSION VINE—PLANTATION 3, THORNLANDS.

Date.	*Thrips tabaci.*	*Thrips imaginis.*	*Taeniothrips kellyanus.*	*Thrips* spp.	*Haplothrips froggatti.*	*Aphis gossypii.*	*Macrosiphum gei.*	*Aphis rumicis.*	*Aphis* spp.	*Acarina.*	Miscellaneous.
10–9–46	56	6	1	..	..	..	1	..	..	..	
2–10–46	9	8	..	1	..	..	..	..	..	..	2 Chrysomelidae
16–10–46	20	10	..	..	..	..	..	..	..	..	4 *Pheidole megacephala*; 1 Entomobryidae
30–10–46	35	2	..	..	..	..	..	..	1	..	3 Psocidae
13–11–46	62	..	..	2	..	..	..	..	..	1	4 Psocidae; 2 Nitidulidae
27–11–46	1	..	..	..	..	..	..	..	..	..	1 Chalcidoidea; 1 Psocidae
11–12–46	..	..	..	..	..	..	..	..	..	..	
8–1–47	..	..	..	..	..	..	..	..	..	..	
5–2–47	2	..	..	..	..	..	..	..	..	1	
19–2–47	..	..	..	..	..	..	..	..	..	..	
13–3–47	..	..	..	..	..	..	..	..	..	1	2 Psocidae
9–4–47	1	..	..	..	..	..	..	..	..	2	4 Psocoptera; 1 *Neophysopus* sp.
23–4–47	..	..	1	..	..	..	..	..	..	14	5 Psocoptera; 1 *Neophysopus* sp.; Lepidopterous eggs
7–5–47	1	..	..	..	..	..	..	..	..	9	1 Psocoptera
22–5–47	..	..	..	1	..	..	..	..	..	7	1 Braconidae
4–6–47	4	..	..	2	..	..	..	..	..	..	
19–6–47	..	..	..	1	..	..	..	..	..	..	3 Psocidae
Total ..	191	26	2	7	..	..	1	..	1	35	

numbers of *Macrosiphum gei*, *A. gossypii* and *A. rumicis* were found on vines in the Springbrook area, and in July 1947, *M. persicae* was again collected from passion vines. *Aphis rumicis* on one occasion (9/6/48) was found colonising passion vine terminals in the Thornlands district. In August 1947, in an infected plantation in the Rochedale area the insect population was found to consist of relatively high numbers of thrips on the flowers, terminals and leaves (*Thrips tabaci* Lind., *T. imaginis* Bagn., *Haplothrips froggatti* Hood) and a number of other insects (including *Triphleps australis* China, *Pheidole megacephala* (F.), and *Lathridius* sp.). No aphids were present on the vines. On the weeds within the plantation, however, *Macrosiphum gei* and *Aphis rumicis* were found to be present in some numbers.

Species of thrips were the insects most constantly present on the vines and they showed peak populations from August to November. The species numerically strongest were *Thrips tabaci* Lind. and *T. imaginis* Bagn.

Jassids were found to be infrequent visitors to the passion vine. They were not detected over the period of these samplings, but it must be noted that the method of sampling was not suitable for the collection of jassids.

Table 6.

INCIDENCE OF INSECTS ON THE PASSION VINE—PLANTATION 4, VICTORIA POINT.

Date.	*Thrips tabaci.*	*Thrips imaginis.*	*Taeniothrips kellyanus.*	*Thrips* spp.	*Haplothrips froggatti.*	*Aphis gossypii.*	*Macrosiphum gei.*	*Aphis rumicis.*	*Aphis* spp.	*Acarina.*	Miscellaneous.
21–8–46	54	4	..	..	4	..	..	..	4	..	2 Lathridiidae
10–9–46	34	3	..	..	..	..	..	..	..	..	
2–10–46	19	16	..	..	..	..	..	..	..	..	1 Chalcidoidea
16–10–46	26	2	..	..	..	..	..	..	..	..	2 Chalcidoidea
30–10–46	12	..	..	..	..	..	..	..	..	..	
13–11–46	51	..	..	..	..	..	..	..	..	..	
27–11–46	1	..	..	..	..	..	..	..	..	..	
11–12–46	7	..	..	..	..	..	..	..	..	..	
8–1–47	7	..	..	..	..	..	..	..	..	..	
5–2–47	..	..	..	..	..	..	..	..	..	..	
19–2–47	..	..	..	..	..	..	..	..	..	..	
13–3–47	..	..	..	..	..	..	..	..	..	..	1 *Empoasca* sp.
27–3–47	..	..	..	..	..	..	..	..	..	8	2 Pseudococcidae
9–4–47	..	..	..	..	1	..	..	..	..	13	1 Psocoptera; 1 Mycetophilidae
7–5–47	..	..	..	1	..	..	..	..	..	4	
22–5–47	1	..	..	..	..	..	..	..	..	2	Lepidopterous larvae; 1 Diptera; 1 Anthocoridae
4–6–47	7	..	..	..	..	2	..	2	..	..	1 Psocidae; 2 Miridae
19–6–47	4	..	..	2	..	..	..	..	..	..	2 Plectoptera; 2 Phalacridae
4–7–47	7	..	..	..	..	..	..	..	..	1	
23–7–47	4	..	..	..	..	..	..	..	..	2	4 *Triphleps australis*
6–8–47	..	..	..	2	..	..	..	..	..	..	2 Diptera; 6 Hemiptera
25–8–47	21	..	..	..	..	..	..	..	..	..	2 Coccinellidae
28–8–47	1	..	..	..	..	..	..	..	..	..	2 *Triphleps australis*; 2 *Nysius vinitor*
12–9–47	59	..	..	..	..	..	..	..	..	2	6 *Triphleps australis*
24–9–47	32	..	..	..	..	..	..	..	..	..	2 Coccinellidae
Total ..	347	25	..	5	5	2	..	2	4	32	

Empoasca terra-reginae Paoli was collected in April and July of 1946 from several areas and *Peregrinus maidis* Ashm. was found on passion vines at Rochedale.

It is concluded that apart from the occasional incidences in epidemic form of pests such as Rutherglen bug (*Nysius vinitor* Berg.), green vegetable bug (*Nezara viridula* (L.)), Queensland fruit fly (*Strumeta tryoni* (Frogg.)) and the passion vine mite (*Tenuipalpus californicus* Banks), the passion vine supports a relatively small insect fauna. While known aphid vectors have been found on the vines, it is concluded that they do not colonise this plant by choice but that they breed on weeds and horticultural plants in and around the plantation. It would therefore appear that infection must be spread by itinerant visits by the vectors concerned.

TRANSMISSION OF THE VIRUS.

In the greenhouse the woodiness virus is readily transmitted mechanically by the glass spatula-carborundum dusting technique at mean maximum temperatures ranging from 72·2°F. to 106·4°F. This technique was employed in the mechanical transmissions referred to in this paper. Inoculum was prepared by macerating infected tissue in water with a mortar and pestle.

In grafting transmissions, the leaf grafting technique of Nattrass (1944) was exclusively employed. In this technique the petiole of the infected leaf is cut wedge-shaped and slipped into a longitudinal cut in the cambium of a healthy seedling. The area is then bound with tacky rubber. The passion vine is very amenable to this treatment and only rarely does a grafted leaf fail to survive. The method is conservative of material, and has the advantage that if in 24 hours the grafted leaf is turgid the success of the graft is then known. Individual leaves infected with the typical mottle (Fig. 14), or with fern leaf (Fig. 15), persisted, grafted to healthy seedlings, for 11-16 months in the greenhouse.

It was also determined that the virus may be transmitted by inserting a small rectangular piece ($\frac{1}{2}$ in. x $\frac{1}{8}$ in.) of infected leaf into a cut in the cambium of the stem of a healthy seedling and binding with tacky rubber. Within a month callus tissue is laid down around the area and transmission of the virus has occurred.

A single attempt to obtain evidence of soil transmission failed. Stem and leaf tissue from infected vines added to soil growing healthy seedlings failed to produce the disease.

Magee (1948) reported that the woodiness virus is identical with cucumber mosaic virus. It was not possible, however, over the course of the investigations, to transfer mechanically various cultures of the woodiness virus in *Passiflora edulis* to tomato (*Lycopersicon esculentum* Mill.), *Datura stramonium* L., cucumber (*Cucumis sativus* L.), *Lupinus mutabilis* Sweet, or tobacco (*Nicotiana tabacum* L.). Eleven separate attempts were made, involving 51 indicator plants over a range of temperatures from 79·0°F. to 100·6°F., the majority of the attempts being made at the higher temperature. At the times of such failures to obtain a response with any of these species, the inoculum used produced the usual reactions on *Passiflora edulis* and *P. alba* Link & Otto.

Temperature Relationship with Expression of Terminal Symptoms.

The bending downwards of the first and second unfolded leaflets along the axis of the main veins in seedling passion vines shortly after they are inoculated with the woodiness virus is a familiar symptom to workers with this virus.

Fig. 14.

Bunching of Terminal and Cessation of Growth Following Leaf Graft with Typical Bullate Mottle. 44 days after grafting. Healthy plant at right.

Employing *Passiflora edulis* and *P. alba* as healthy seedlings, and using various isolates of the virus in *P. edulis* as inoculum, it was found, both by leaf graft and by mechanical transmissions, that the time taken for the appearance of the terminal symptoms is governed by temperature.

Fig. 15.

Left, plant grafted with typical bullate mottle (note terminal reaction). Right, grafted with fern leaf (note absence of terminal reaction). Both 12 days after grafting.

The terminal symptoms may be expressed in as short a time as six days, with a mean of seven days, when the mean maximum temperature is 98·1°F. (in November). When the mean maximum temperature drops to 83·2°F. (April), the mean time for appearance of terminal symptoms is extended to 8·8 days, while in the coolest months (May, June, July), when the mean maximum varies from 73·2°F., to 79·5°F., the mean time taken for terminal symptoms to appear is 24·6 days.

REACTIONS OF OTHER SPECIES OF PASSIFLORA TO THE WOODINESS VIRUS.

In the course of these investigations the reactions of other commonly occurring species of *Passiflora* to the woodiness virus were determined.

P. suberosa L.—In the field *P. suberosa* may be observed showing in the older leaves a fleeting light-green mottle with which large light-green spots may be associated. There may also be very slight rugosity on some of the young leaves. On several occasions during the summer and winter months, inoculations from such material failed to produce symptoms in *P. edulis* L., *P. foetida* L., *P. edulis* Sims forma *flavicarpa* O. Degener, or *P. alba*. Conversely, attempts to infect *P. suberosa* with virulent cultures of woodiness virus in *P. edulis* failed. Finally, to determine whether masking of the virus occurred in the last-mentioned tests, the symptomless *P. suberosa* plants were inoculated to *P. alba;* no response was obtained.

P. edulis f. *flavicarpa*.—This species reacts readily to inoculation with the woodiness virus. In the cooler months it produces symptoms similar to those shown by *P. edulis*, with the exception that the yellow spot mottle has a special affinity with this species. Twenty-seven days after inoculation with *P. edulis* material showing the typical mottle and yellow spot mottle, the young terminal leaves of *P. edulis* f. *flavicarpa* show vein clearing and are downcurled; the yellow spot mottle is conspicuously shown on the older leaves, with the yellow spots large and discrete. The petiole mottle on this species is more marked than in *P. edulis*.

Over the spring months the new growth on infected *P. edulis* f. *flavicarpa* plants is relatively normal, but there may be some asymmetry of leaves. In early summer, the plants again show the typical terminal symptoms accompanied by conspicuous discrete yellow mottle on the older leaves, unaccompanied by rugosity.

P. foetida.—Marked reaction of this species to the virus of the typical mottle is shown (Fig. 16). Infected seedlings may die within 33-53 days after inoculation during the winter months. Fourteen days after inoculations made in the cooler months the last three unfolded leaves show a violent spiral twisting accompanied by downcurling along the main veins, and a prominent green veinbanding and yellowing of interveinal areas occurs. Green veinbanding occurs also in the older leaves. Twenty-six days after inoculation the leaves become bright yellow with a filigree of green veins.

P. alba.—This species is highly susceptible to woodiness. It is a small, easily-grown plant that can be repeatedly pruned and is an excellent species for greenhouse work with the virus.

When the mean maximum temperature varies from 91·5°F. to 106·4°F. (October to March), symptoms are masked in the new growth of systemically infected *P. alba* plants. However, if inoculations are made to seedlings of

Fig. 16.
Terminal Symptoms in *Passiflora foetida* 14 days After Inoculation.
Healthy plant at right.

P. alba over this temperature range, terminal symptoms will appear in 9-11 days; they consist of vein clearing in the first or first and second unfolded leaves, wilting of the petioles, downcurling of the leaves along the main veins and the appearance of a yellow green mottle.

When such plants are held in the greenhouse, and the mean maximum temperature drops to 79·0°F., they suffer from a crippling disease. There is a marked reduction in the growth of laterals and terminals, the majority of leaves on the plants are cupped downwards along their main veins, and individual leaflet lobes have their margins cupped under along the main veins. The leaves have a prominent yellow or yellowish-light-green mottle, with the lighter areas occurring in patches interveinally to produce a light-green veinbanding. These symptoms persisted until September (mean maximum temperature 81·2°F.).

From October to March (mean maximum temperatures 91.5°F. to 106·4°F.), the symptoms were masked in new growth; in the following April (mean maximum temperature 83·2°F.), translucent areas reappeared in the first unfolded leaflets accompanied by vein clearing. The symptoms of the previous winter were then repeated, accompanied by violent clearing and leaf distortion in the new growth. Stipules or leaf sheaths show similar mottle to the leaves.

The yellow spot and ring spot mottle may occur when *P. alba* is inoculated with suitable material. The symptoms first appearing after inoculation vary considerably in intensity, depending on the isolate of

woodiness virus used (e.g., the typical woodiness mottle produces a more severe reaction than fern leaf material). A virulent culture of the typical woodiness mottle produces a more severe clearing of the first and second leaves which may involve the greater portion of the leaf. Older leaves may also show marked downward cupping of the leaflet lobes along the main veins, accompanied by a curling-under of the leaf margins. The leaf mottle may be so intense as to produce an almost yellow leaf.

Fern leaves on *P. alba* have not been observed in nature. Several isolates of the woodiness virus from *P. edulis*, however, produced fern leaves in *P. alba* in the greenhouse.

Passiflora alba, P. foetida and *P. suberosa* occur wild throughout south-eastern Queensland. Of these, *P. alba* is a common component of the flora of the mountain and hill country. It is almost universally infected with the woodiness virus and is considered to be an important natural reservoir of infection.

MECHANICAL TRANSMISSION BY SECATEURS.

During pruning operations in the field many successive cuts are made on the laterals of one vine before proceeding to the next vine. As populations of the known aphid vectors seemed inadequate to explain the epiphytotic incidence of the virus in plantations in which pruning was carried out, two tests were made to determine the extent of transmission of the virus by pruning with secateurs.

Test No. 1.

A typically infected passion vine was taken from the field in June 1947, and with this material two tests were made in the greenhouse.

1. Three infected terminals were bunched together and cut six times with the secateurs, which were then used to cut the terminal of a healthy passion vine seedling. This test was repeated five times.

2. Typically mottled leaves were ground in water to produce a thick extract. The secateurs were dipped in this extract and a cut was then made across the terminal of a healthy plant. This test was repeated four times.

After 16 days the results were as follows:—

Treatment 1: 3 out of 5 infected.
Treatment 2: 2 out of 4 infected.

The plants were maintained in the greenhouse for four months without any alteration to the above figures.

Test No. 2.

This was carried out on March 23, 1948, and as evidence obtained prior to this date indicated that the fern leaf component in combination with the yellow spot and ring spot mottles differed from the typical mottle in the same combination two distinct cultures of the virus were employed—the typical and the fern leaf.

Forty-one 4-month-old passion vines were treated in the following manner:—

(1) A healthy passion vine received one cut with secateurs after one cut had been made on the stem of a seedling infected with the typical woodiness (Plant 89). This test was repeated 20 times.

(2) A healthy passion vine received one cut with secateurs after one cut had been made on the stem of a seedling infected with fern leaf type (Plant 88). This test was repeated 21 times.

The results obtained are shown in Table 7 and illustrated in Fig. 17.

Table 7.

NUMBER OF PLANTS SHOWING SYMPTOMS.

Symptom.		Terminal Reaction.				Bullate Mottle.	Fern Leaves.			No Symptoms.
Days after Inoculation.		7	13	16	37	90	90	130	155	—
Source.	Number Inoculated.									
Typical	20	1	10	11	11	11	0	0	1	9
Fern Leaf ..	21	0	1*	0	2	3	1	6	7	11

* Terminal reaction not present on 16th day.

Ninety days after the secateur transmissions were made the symptoms displayed by the plants in the ex fern leaf and the ex typical were quite different. The ex typical showed no fern leaves but exhibited a prominent bullate mottle, with the green colour confined to the raised areas and the remaining areas of the leaves light-green or cleared. Three plants of the ex fern leaf showed similar symptoms to the ex typical, but one of the other ex fern leaf plants had produced five fern leaves uncontaminated with the typical mottle. The ex typical were producing new growth slowly while the ex fern leaf (with the above exceptions) remained green and grew relatively normally.

At 130 days after inoculation, six of the ex fern leaf plants had produced fern leaves in the first and second leaves, while there were no fern leaves present in the ex typical.

At 155 days after inoculation, seven of the ex fern leaf plants were consistently producing fern leaves in the new growth and the yellow spot mottle was present on the older leaves. Vein clearing occurred in the terminal leaves but the plants were generally green in colour and making reasonably good growth. At this time 10 of the 11 infected plants in the ex typical had ceased growth in the majority of terminals and showed the typical mottle accompanied by marked translucent areas and vein clearing in the terminals. The yellow spot mottle was present on the older leaves and a bunching, twisting and marginal waving of the young leaves occurred. Foliage

Fig. 17.
Difference in Symptoms Produced in Secateur Transmission Test. Left, ex 88 (fern leaf). Right, ex 89 (typical).

colour generally was a light-green. It would appear that the "typical" isolate produced a crippling disease, whereas the "fern leaf" isolate had a significantly milder effect.

The one remaining infected plant in the ex typical produced two fern leaves and a yellow spot mottle on the older leaves.

Nine days after the conclusion of the secateur transmission trial, detailed observations were made on six plants of the ex 88 and five of the ex 89. A summary of these is contained in Table 8.

Table 8.

SYMPTOM EXPRESSION FOLLOWING INOCULATION WITH FERN LEAF AND TYPICAL STRAINS OF THE WOODINESS VIRUS.

Accn. Number.	Total Number Leaves.	Number Fern Leaves.	Number with Typical Mottle.	Number with Yellow Spot Mottle	Number with Ring Spot.	Terminal Vein Clearing.
		From 88 (ex fern leaf).				
1 ..	25	8	—	—	—	+
2 ..	5	1	—	—	—	+
3 ..	12	4	—	—	—	+
4 ..	32	4	—	1	—	+
5 ..	31	6	1	—	—	+
6 ..	29	1	2	6	2	+
		From 89 (ex typical).				
1 ..	13	—	3	2	—	+
2 ..	18	1	7	1	—	+
3 ..	22	—	6	1	—	+
4 ..	16	—	8	5	—	+
5 ..	32	? 1	5	8	—	+

Summary :	Total Number Leaves.	Percentage Fern Leaves.	Percentage Typical Mottle
From 88 (ex Fern leaf)	134	18	2
From 89 (ex Typical)	101	2	29

Fig. 18.

Fern Leaf Transmitted Mechanically and Uncontaminated with the Typical Mottle.

Fig. 19.

Grafting Transmission Tests. Left-hand Pair, 57 days after grafting. Right-hand Pair, same pair 154 days after grafting. Note persistence of grafted leaves. The plant at the left in each case was inoculated with fern leaf and shows no terminal reaction; that on the right was inoculated with typical mottle and a terminal reaction is shown.

It was found that while other symptoms of the virus (yellow spot mottle, terminal vein clearing) remained present in the two sources of the virus used in this test, it was possible to obtain a number of plants (1–4 from ex 88) which produced fern leaves uncontaminated with the typical mottle (Fig. 18), and three plants (1, 3 and 4 in the ex 89) which produced the typical mottle uncontaminated with the fern leaf.

It was then shown, by taking fern leaves from the ex 88 plants and by taking typical mottle leaves from the ex 89 plants and leaf grafting to healthy passion vine seedlings, that the typical mottle component is responsible for the terminal bending and twisting symptoms, while the fern leaf component is unable to produce the terminal reaction (Fig. 19). For 46 days after leaf grafting with fern leaves the seedlings remained normal and exhibited no terminal reaction or mottle. Fifteen days after leaf grafting with the typical mottle, the seedlings showed the usual marked terminal reaction. Forty-six days after inoculation the plants had ceased to grow and showed bunching of the terminals and yellow spot mottle.

STRAIN COMPLEX HYPOTHESIS

Nattrass (1940, 1944) referred to a form of the woodiness virus which produced little or no effect on the foliage but which produced woody fruit, and also to three other distinct types present in parts of Kenya. Unfortunately, no description of these three types was given. The form producing little or no foliage effect but producing woody fruit has not been encountered in Queensland.

Hitherto, the woodiness virus as it occurs in Australia has been regarded as a single entity. However, during the course of greenhouse experiments and field observations, evidence has consistently appeared to support the view that this virus exists as a complex of strains. This evidence is summarised below.

During greenhouse transmissions it was found that when leaves infected with typical mottle were inoculated into healthy seedlings the whole series of symptoms characteristic of the virus were produced. From such infected seedlings selections were made of the fern leaf, yellow spot mottle, ring spot mottle and typical mottle components and by leaf-grafting and by mechanical transmissions in a new series of plants the majority of such transmissions were found to reproduce again the whole series of symptoms of the virus. From a number of transmissions, however,—

(1) It was found possible to exclude the typical leaf mottle from the range of symptoms by selecting fern leaves for leaf grafts which were contaminated by the yellow spot mottle only. Such fern leaf grafts were shown to be unable to produce the terminal reaction, while grafts of the typical mottled leaves carried out at the same time did produce this reaction.

No acceleration in time in producing fern leaves occurred by selecting fern leaves for grafts as compared with selecting typical mottle for grafting; neither was there any difference in time in the production of fern leaves by employing typical or fern leaf material for mechanical transmissions.

It was shown that simultaneous leaf grafting to separate leaders of the one plant of the typical mottle and the fern leaf component results in a positive terminal reaction on the leader grafted with the typical mottle, and a negative reaction on the leader grafted with the fern leaf.

(2) It was determined that inoculation from the fern leaf component segregated from the typical mottle, and contaminated only by the yellow spot mottle, produces reasonably good growth.

QUEENSLAND HOST RECORDS FOR THE DACINAE (*fam.* Trypetidae).

By A. W. S. MAY, M.Agr.Sc., Entomologist, Science Branch, Division of Plant Industry.

SUMMARY.

A comprehensive host list for the Dacinae occurring in Queensland has been compiled from data recorded following the collection of 350 species of cultivated, ornamental and wild fruits representing 75 botanical families. Records published by earlier authors and unpublished records from various sources are included.

Thirteen genera of Dacinae, with 39 species, are involved and arguments are given for the system of presentation of the genera. The status of certain species, particularly those forming the tryoni complex, needs some revision but deferring this question is not prejudicial to the form of presentation adopted in this paper. Several synonyms are recognized and these are discussed only in so far as they affect the purpose of this list. The recognition of food forms among several species has necessitated the sinking of many previously recognized varieties. The significance of these colour variants is discussed under the relevant species.

Strumeta tryoni (Frogg.). the most important economic fruit fly in Queensland, has been bred from 106 hosts.

Methods used in collecting, breeding, and cage rearing to facilitate identification of Dacinae are given.

The records, with suitable notes, are presented in two sections. The first is a list of fruit flies with their hosts. In the second, hosts are arranged alphabetically for family, genus and species. The species of Dacinae are tabulated under their respective hosts.

INTRODUCTION.

All species of the subfamily Dacinae (fam. Trypetidae) recorded in Queensland are indigenous, and although some of their native hosts are located in open forest or along watercourses, the majority are found in rain-forest. With the development of commercial fruit growing, several of these species have turned their attention to cultivated fruits, and three species—*Strumeta tryoni* (Frogg.), *S. musae* (Tryon) and *Austrodacus cucumis* (French)—have become important pests. The first-mentioned species is by far the most destructive, and due to its depredations, the growing of some fruits is not a commercial proposition in certain areas, while in others a reduction in the quantity of harvested fruit may be expected in most years.

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Over the past 10 years, investigation of the fruit fly problem has been intensified, and one phase of the work has been the recording of the host fruits of the many species found in Queensland. Earlier workers in this State also devoted some time to this aspect of the problem, though a great many of their records were not published. During the current investigations, opportunity was found to check most of the earlier records.

Previous workers have covered most coastal and subcoastal regions in their search for host records, but during the course of these studies many new host records and several new fruit-fly species have been added to the already imposing list from within these areas. On the other hand, despite extensive search, several long recognized species have not been correlated with their native hosts, their presence in these parts of Queensland being recognized merely from specimens attracted to lure traps in commercial orchards.

Fruit fly trapping stations* established in widely separated and climatically diverse regions of the State and maintained for varying periods over the past 10 years have also revealed further new fruit fly species. Though the hosts of many of these species are not known, their fruiting season had been suggested by the trapping data. This information and consequent search have resulted in additions to the host list records.

The short-term collecting of hosts has been found unsatisfactory for a general study of fruit fly-host relationships. Many trees and shrubs may not fruit in a drought-year. Furthermore, a fruit fly species may not be recovered from less susceptible hosts in a year when its numbers are low, unless large samples of fruits can be collected over a wide range of territory. Thus, older records may not be confirmed and newer ones established unless collecting is continued over many seasons. This host list, therefore, is by no means an exhaustive one and it is anticipated that further records will warrant supplementary lists.

During these investigations it became apparent that the many fruits collected could be divided roughly into three classes. The first includes those regularly infested by fruit fly larvae. The majority in this group are native fruits, including the only known host of a species, though many cultivated fruits when growing in certain districts could be included. A second and much larger group includes those fruits infested only under certain conditions, particularly the locality where the fruit was growing, the month when collected, fruit susceptibility and the effect of seasonal conditions on fly abundance. The majority of the host records presented fit into this group. Finally, there are those fruits that have never been associated with fruit fly infestation despite many collections from areas of known fly activity or in close proximity to infested fruits of well-known hosts. Some cultivated fruits, as well as a great many native ones, fit into this category. As examples, pineapples (*Ananas comosus* (L.) Merr.) and strawberries (*Fragaria indica* Andr.) are grown intensively throughout coastal districts where all fruit fly species

* These stations were established primarily to study dispersal and seasonal abundance.

recorded in Queensland are known to occur. Despite many collections by various investigators over the past 40 years, these two fruits have never been recorded as fruit fly hosts.

The records presented should be regarded purely as a host list. A large number of commercial hosts are listed under several fruit fly species, but these fruits are not always infested in the field and their inclusion merely shows that the species in question may breed in them occasionally.

Only field-collected hosts, naturally infested, have been used for these records. The inclusion of laboratory-infested material other than for a specific reason would be misleading.

METHODS.

Collecting and Breeding.

The greater portion of the field work covered by these studies was undertaken in the coastal and subcoastal regions between the Daintree River in North Queensland and the southern border of the State, particularly where rain-forest abounds. Only chance records were obtained west of the Dividing Range.

Since 1942, fruits representative of 75 botanical families and involving approximately 350 species have been collected. Some species were taken several times from the same locality as well as from various localities throughout the State.

During field collecting, ripe fruits were gathered either directly from the tree or from the ground. Samples as large as possible were collected, and placed in stout brown-paper bags on which the locality, date and other relevant information was recorded. Similar species of fruit from different localities were always bagged separately.

In the laboratory, each sample was mixed with moistened sawdust, placed in a large glass jar suitably labelled, and covered with muslin or cheesecloth held in place with rubber bands. Each jar was fitted with a test tube inserted a short distance through a hole cut in the cloth cover. As the flies emerged* into the tube they were transferred to cages, and maintained with food for at least a month before being mounted. In this way, the flies developed normal colour patterns and tended to maintain normal shape and appearance after pinning. This made identification easier.

Two standard type cages were used, one measuring 18 in. x 12 in. x 15 in. and the other 36 in. x 15 in. x 15 in. Both were covered with muslin on three sides, and on the front with removable glass on each side of a wooden door. Pressed board or $\frac{3}{16}$ in. plywood covered both top and bottom.

* Over the years, parasites were often associated with fly infested fruits but did not interfere with this work. These records will be dealt with elsewhere.

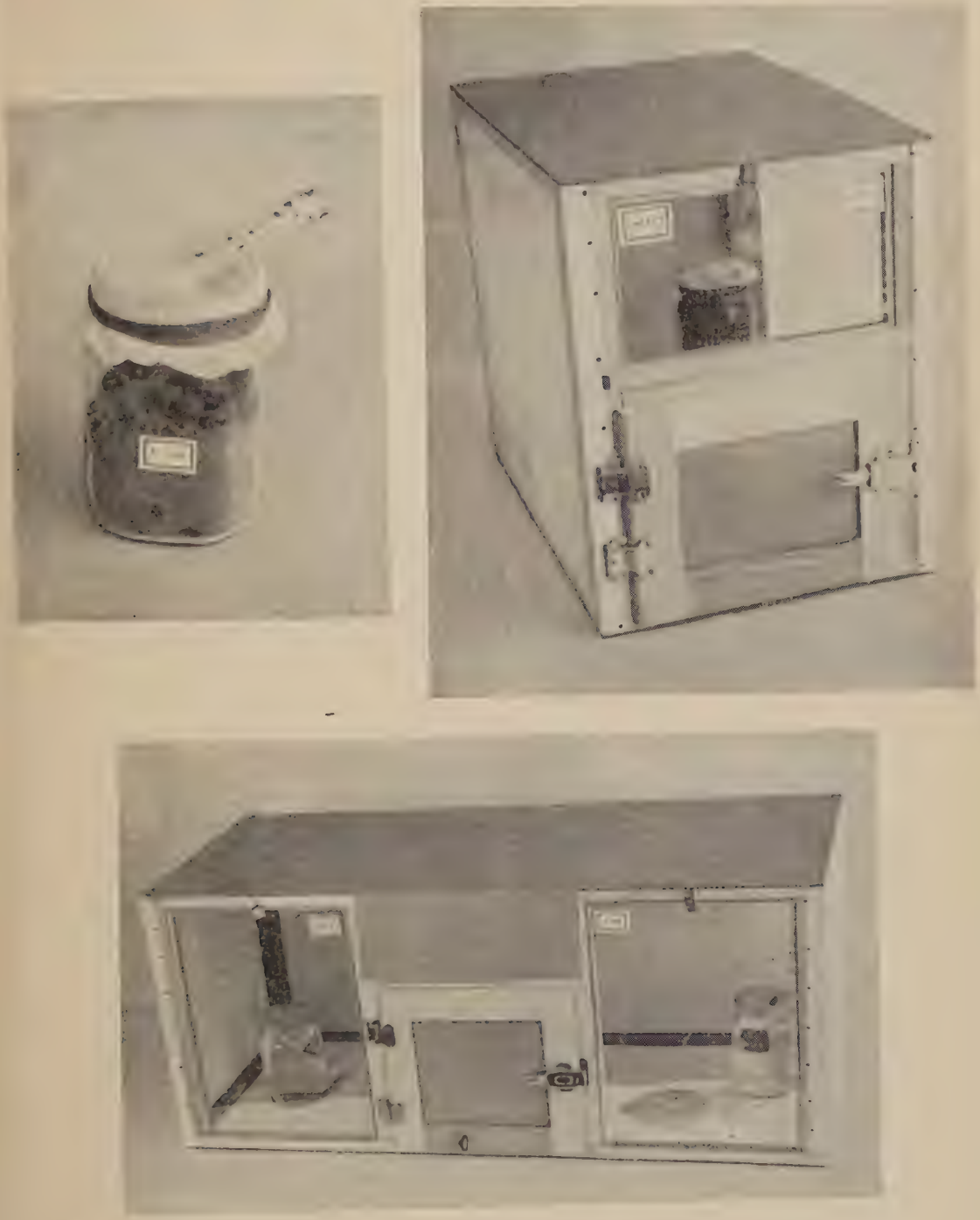

Fig. 1.

Apparatus for Collecting and Breeding Fruit Flies. Top left, emergence jar with muslin cover and tube fitted. Top right, smaller rearing cage. Bottom, larger rearing cage, showing water bottles and prepared food in petri dish.

Water was provided in each cage in 2 lb. glass jars fitted on top with 4 in. diameter circular pads of blotting paper from which a blotting paper wick hung into the water. Food consisted of (1) a prepared agar base medium containing brewer's yeast, sucrose, citric acid, fruit pulp and a mould preventive, (2) slices of apple or orange renewed every second or third day, and (3) honey smeared on small rectangles of glass which were removed, washed and replenished every second or third day.

Revision of Previous Records.

During the search for new records, every attempt was made to check those of earlier collectors. In some instances, closer settlement had resulted in the clearing of many rain-forest areas and with it the trees from which these records were established. On other occasions, when fruits were obtained they were not infested. There is the probability, however, that some of these unconfirmed records are valid and only results from repeated collecting over a number of years will substantiate them.

In compiling the host list, records additional to those obtained during the current investigations have been drawn from the published works of Froggatt (1909), Tryon (1927), Perkins (1934), Perkins and May (1949) and Hardy (1951). Further records have been obtained from examination of specimens in the fruit fly collections of the Queensland Department of Agriculture and Stock, the University of Queensland and the Queensland Museum. A revision of the determinations was often necessary in accordance with the present species concept.

Identification of Flies.

The species of Dacinae covered in this paper have been grouped according to the generic classification adopted by Perkins (1937) and added to by more recent workers. This classification may need revision*, but for the purpose of this paper it presents less likelihood of ambiguity than an entire subgeneric classification as presented by Hardy (1951).

Several synonyms have been established and these are discussed, as far as they concern this paper, under the relevant species. Some other species warrant further investigation but at this juncture (see footnote*) no attempt has been made to alter their present status. The existence of a number of closely related species, for convenience referred to as the *tryoni* complex, has also created some difficulty in presenting this host list.

Variations shown by laboratory-bred material were appreciated during these investigations. Abnormalities in chaetotaxy and size and in area and density of colour were noticed. These variations have been recognized by previous workers and in some instances have been considered a basis for varietal status. With field specimens these criteria are more uniform.

*A revision will be considered when current breeding and cytological studies are more advanced.

Tryon (1927) recognized varietal forms of *Strumeta tryoni* (Frogg.), *S. cacuminata* Hering, *S. musae* (Tryon) and *Afrodacus jarvisi* (Tryon). Laboratory breeding experiments* have now revealed that these are merely forms differing from the species in size and colour and the variations are attributable to food relationships during development within the host. Other species—*S. halfordiae* (Tryon), *S. pallidus* Perk. & May and *Austrodacus cucumis* (French)—also exhibit these colour forms among laboratory-reared and field-trapped material. The several forms are discussed further in the host list.

Botanical Identifications.

All botanical names, whether recent identifications or revisions, have been provided by officers of the Botany Section of the Department of Agriculture and Stock.

PRESENTATION OF DATA.

The records are presented in two sections.

The first section, more detailed than the second, lists the various host plants under each fruit fly species. The hosts are subdivided into wild, ornamental and commercial. The first include indigenous flora as well as those introduced plants well established in the wild state. Ornamentals include shrubs and trees cultivated for their ornamental value and which do not occur in the wild state. Commercial hosts include all vegetables, vines, shrubs and trees grown for commercial fruit production. Under each heading host names are arranged alphabetically according to family and genus. Where host names have been revised the names used in earlier host lists are indicated.

Fig. 2.

Solanum auriculatum Ait., Host of the Solanum Fly (*Strumeta cacuminata* Hering).

* Studies concerned with food requirements and colour variations are continuing.

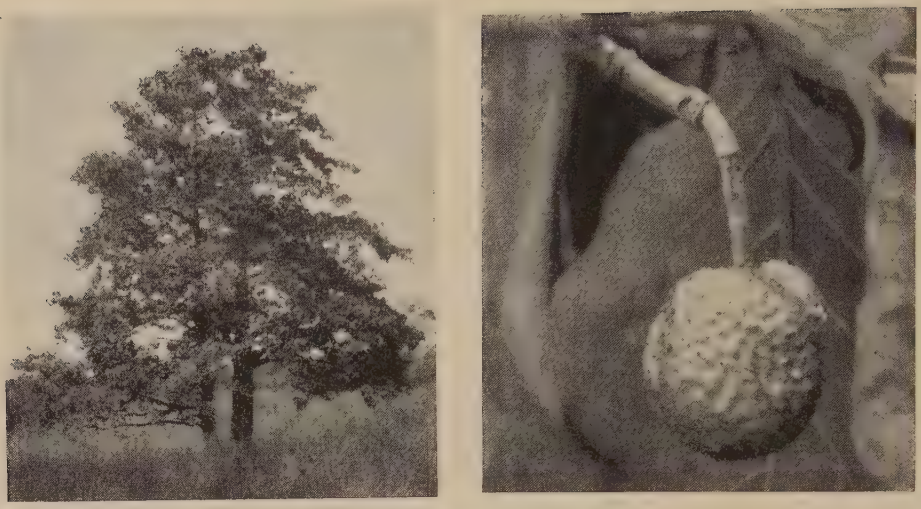

Fig. 3.

Nauclea orientalis L. (Leichhardt Tree or Canary Wood), the Only Known Host of *Strumeta pallidus* Perk. & May.

The order of presentation bears no relationship to host preferences. In general, susceptibilities of commercial host varieties to fruit fly attack are not discussed as these are dependent on several factors. There are, however, some instances that warrant discussion and these are given special mention.

All earlier records which have not been confirmed by the present author are marked by a symbol denoting the author of the record. Those considered doubtful for the species under which they were originally published are listed separately and discussed.

The key to the symbol notation is as follows:—

(T) = Tryon (1927).
(P) = Perkins (1934).
(P & M) = Perkins and May (1949).
(H) = Hardy (1951).
(DAS) = Dept. Agriculture and Stock Collection, Brisbane.
(UQ) = University of Queensland Collection.

The months of the year when fly attacks on each host were recorded are given. These data, however, are far from complete. To some extent fruiting period will vary with locality and seasonal conditions.

Those species for which host records are unknown are discussed under their respective genera.

In the second section, hosts are arranged alphabetically for family, genus and species. The species of fruit flies are tabulated under their respective hosts. In addition, concise relevant notes are given for appropriate records.

SECTION 1.

Fruit Fly–Host List.

Host records are arranged under the respective fruit fly species. This list contains records for 13 genera with 39 species.

AFRODACUS Bezzi.

Afrodacus jarvisi (Tryon).

= *Chaetodacus jarvisi* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14): pp. 201-3.

C. jarvisi var. *careya* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14): p. 202.

Dacus (*Chaetodacus*) *australis* Hendel 1928. Ent. Mitt.: 17 (5): pp. 341-2.

Laboratory breeding has shown that Tryon's var. *careya** is merely a melanic form of *A. jarvisi* which arises following a deficient food supply during the larval stages. These are small flies.

Commercial Hosts.

Ebenaceae.

Diospyros kaki L. f.—Persimmon: March.

Punicaceae.

Punica granatum L.—Pomegranate: April.

Rosaceae.

Cydonia oblonga Mill.—Quince: April (T).

Prunus armeniaca L.—Apricot: (T).

Prunus persica (L.) Batsch—Peach: March.

Pyrus communis L.—Pear: December and April.

This species will sting and breed readily in apples (*Malus sylvestris* Mill.) in the laboratory.

Wild Hosts.

Anacardiaceae.

Semecarpus australiensis Engl.—Tar tree: December (H). This host more usually supports the similarly coloured *Daculus murrayi* Perk. (see p. 46).

Barringtoniaceae.

Planchonia careya (F. Muell.) R. Knuth (= *Careya australis* F. Muell.) —Cockatoo apple: November to March. This host, found quite commonly in the coastal regions north from Bundaberg, breeds *A. jarvisi* in very large numbers each year.

* Tryon (1927) has not commented on differences necessary to distinguish his var. *careya*, but merely refers to its existence as a type (Reg. No. Q.M.D. 3132) in the Queensland Museum.

Combretaceae.

Terminalia catappa L.—Tropical almond: (H).

Myrtaceae.

Eugenia cormiflora F. Muell.: December (H).

Psidium guajava L.—Guava: March to July—an important host in the northern regions of the State.

Males of this species are attracted in large numbers to the flowers of several plants, including *Bulbophyllum baileyi* F. Muell. (fam. *Orchidaceae*), *Passiflora ligularis* Juss. (fam. *Passifloraceae*) and *Semecarpus australiensis* Engl. (fam. *Anacardiaceae*), an association quite unrelated to the known host range of the species.

Afrodacus mesoniger May.

= *Afrodacus aberrans* Hardy 1951. Pacif. Sci. 5 (2): pp. 118-20.

Wild Hosts.

Lauraceae.

Litsea leefeana (F. Muell.) Merr. (= *Litsea ferruginea* (R.Br.) F. M. Bail.)—a Bollywood: December.

Litsea reticulata (Meissn.) Benth.—a Bollywood: December.

Neolitsea involucrata (Lam.) Alston (= *Litsea zeylanica* Nees.)—Grey bollywood: February.

Afrodacus brunneus Perk. & May and **A. tigrinus** May.

These two species have been recorded from lure traps only. To date repeated search has failed to reveal their hosts.

ASIADACUS Perk.

Asiadacus calophylli Perk. & May.

This species was placed in *Gymnodacus* Munro by Hardy (1951). Its true position is in some doubt, although there is evidence of a slight undulation at the end of the $Cu_1 + 1A$ vein, suggesting very weak development of a supernumerary lobe.

Wild Host.

Guttiferae.

Calophyllum inophyllum L.—Calophyllum: July-September and February (P. & M.).

AUSTRODACUS Perk.

Austrodacus cucumis (French).

= *Dacus tryoni* Frogg. var. *cucumis* French 1907.
J. Dept. Agric. Vic. 5(5): p. 307.

Dacus cucumis French 1910. Proc. Linn. Soc.
N.S.W. 35 (4): p. 886.

This species, commonly known as the cucumber fly, is a major pest of cucurbits, tomatoes, and papaws, particularly in the northern areas of Queensland. Though sound fruits are stung, fruits that have been allowed to ripen in the field, become sunburnt, or damaged by other means, are readily attacked. Oviposition in young fruits of many cultivated cucurbits causes malformation and stunting.

Commercial Hosts.

Caricaceae.

Carica papaya L.—Papaw: September.

Cucurbitaceae.

Cucurbita pepo L.—Pumpkin: Winter, spring and early summer—more usually associated with damaged fruits or fruits in early stages of development.

Cucurbita pepo L. var. *medullosa* Alef.—Marrow: (T)—damaging fruit especially when newly formed.

Cucurbita pepo L. var. *melopepo* Alef.—Squash: Winter, spring and early summer (DAS). Fruits in early stages of development are often damaged.

Cucumis melo L.—Rock melon: chiefly associated with ripe or sunburnt fruits.

Cucumis sativus L.—Cucumber: Winter, spring and early summer—a major pest of this crop in North Queensland and may deposit eggs in newly formed fruits, causing malformation and stunting.

Sechium edule Sw.—Choko: Summer. Females seen to oviposit in developing fruits. Larval development in this fruit has not been established.

Solanaceae.

Lycopersicon esculentum Mill.—Tomato: Spring and early summer. More usually ripened fruits or those exhibiting growth cracks or mechanical injury are stung. When sound fruits are attacked, the eggs are generally deposited at the calyx end.

Wild Hosts.

Cucurbitaceae.

Bryonopsis laciniosa (L.) Naud. (= *Bryonia laciniosa* L.)—Native bryony: May, July and November—associated with this host more particularly in North Queensland.

Momordica charantia L.—Chinese bitter cucumber or balsam pear: June.

Euphorbiaceae.

Glochidion harveyanum Domin: (H). This record has not been confirmed and seems quite unrelated to the more usual behaviour of this species.

CALLANTRA Walk.
= *Mellesis* Bezzi 1916.

Callantra aequalis (Coq.).
= *Dacus aequalis* Coq. 1909. Proc. Linn. Soc. N.S.W. 33 (4): pp. 794-5.

Though this species has been taken quite commonly for many years in lure traps in southern Queensland, its native host has not been recorded. Froggatt (1909) bred this fly from orange (*Citrus sinensis* Osbeck) at Gosford, N.S.W., and the specimens furnished the material for Coquillet's description. However, no additional records of this species having been bred from either cultivated or native hosts can be found.

DACULUS Speis.
Daculus murrayi Perk.
Wild Host.

Anacardiaceae.

Semecarpus australiensis Engl.—Tar tree: December-January—fruits usually heavily infested.

Fig. 4.
Fruit of *Psidium guajava* L., a Common Host for Several Species of *Dacinae*.

DIPLODACUS May.

This genus was erected from a large series of specimens to accommodate the only known species listed below. Variation occurs in the degree of development of the secondary scutellar bristles and some specimens appear to fit into the genus *Daculus**. However, though inconspicuous, these bristles can be seen quite readily under magnification. The majority of specimens show these bristles well developed.

Diplodacus signatifer (Tryon).

= *Dacus signatifer* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14) : pp. 210-11.

Wild Host.

Capparidaceae.

† *Capparis lucida* (DC.) R. Br. ex Benth.: December to April. Fruits can generally be found on this shrub at most periods of the year.

HETERODACULUS Hardy.

Heterodaculus visendus Hardy.

Wild Host.

Guttiferae.

Garcinia kajewskii C. T. White—a Native mangosteen: January (H).

MELANODACUS Perk.

Melanodacus niger (Tryon).

= *Dacus niger* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14) : pp. 211-12.

Wild Hosts.

Icacinaceae.

Gomphandra australiana F. Muell.: August.

Oleaceae.

Olea paniculata R. Br.—Native olive: August.

Symplocaceae.

Symplocos thwaitesii F. Muell.: (T).

NEODACUS Perk.

Neodacus newmani Perk.

Though described from north-western Australia, where it was bred from native fruits, this species has been taken in lure traps at Toowoomba and Stanthorpe. No host records are available.

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* Hardy (1951) discussed *D. signatifer* under the genus *Daculus*.

† Tryon (1927) wrongly listed this host as *Capparis laurifolia* R. Br.

NEOZEUGODACUS May.

= *Hemizeugodacus* Hardy 1951. Pacif. Sci. 5 (2): p. 131.

Neozeugodacus algaiae (Hardy).

Wild Hosts.

Meliaceae.

Aglaia ferruginea White & Francis: November (H).

Aglaia sapindina (F. Muell.) Harms (= *Hearnia sapindina* F. Muell.): February (H).

Neozeugodacus aureus May.

Wild Host.

Alangiaceae.

Alangium villosum (Bl.) Wangerin sub-sp. *tomentosum* (F. Muell.) Bloemb. var. *australe* Bloemb. (= *Marlea vitiensis* Auct.)—Muskwood: February.

PARATRIDACUS Shiraki.

Paratridacus expandens (Walk.).

=*Dacus expandens* Walk. 1859. Proc. Linn. Soc. London 3: p. 114.

Bactrocera garciniae Bezzi 1913. Mem. Ind. Mus. 3: pp. 97-8.

Dacus yayeyamanus Matsumura 1916. Thousand Insects of Japan, Addit. 2: p. 412.

Ornamental Host.

Guttiferae.

Garcinia tinctoria (DC.) W. F. Wight: May (UQ) and August-November (H).

STRUMETA Walk.

= *Dasyneura* Saunders 1841 (nec. Rondani 1840).
Chaetodacus Bezzi 1913.
Marquesadacus Mall. 1932.

Strumeta alyxiae May.

Wild Host.

Apocynaceae.

Alyxia spicata R. Br.—a Chain-fruit: August.

Strumeta bancroftii (Tryon).

= *Chaetodacus bancroftii* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14): pp. 199-201.

Wild Host.

Moraceae.

Cudrania javanensis Trécul.—Indian cockspur: December-February. The fruit of this host is always heavily infested.

Strumeta barringtoniae (Tryon).

= *Chaetodacus barringtoniae* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14): pp. 196-7.

Wild Host.

Barringtoniaceae.

Barringtonia calyptrata R. Br.—a Barringtonia: February (UQ) and (T)—fruits usually heavily infested.

Strumeta bilineata Perk. & May.

= *Dacus* (*Strumeta*) *mayi* Hardy 1951. Pacif. Sci. 5 (2): pp. 161-2.

Commercial Host.

Rosaceae.

Prunus armeniaca L.—Apricot: November—only very occasional specimens bred in certain years.

Wild Hosts.

Sapotaceae.

Planchonella australis (R. Br.) Pierre (= *Sideroxylon australe* (R. Br.) F. M. Bail.)—Black apple: November (UQ).

Planchonella obovata (R. Br.) H. J. Lam: August-September.

Planchonella pohlmaniana (F. Muell.) Pierre ex Dubard (= *Sideroxylon pohlmanianum* (F. Muell.) F. M. Bail.)—Yellow boxwood: November (DAS).

Combretaceae.

Terminalia muelleri Benth.: August (UQ). This record has not been confirmed, though several collections of this host were made during July-August.

Strumeta breviaculeus Hardy.

Wild Hosts.

Euphorbiaceae.

Glochidion harveyanum Domin: August and December (H).

Myrtaceae.

Psidium guajava L.—Guava: April (H). The correct identification of the flies associated with this record is in some doubt (*vide* Hardy, 1951, pp. 147-8).

Strumeta bryoniae (Tryon).

= *Chaetodacus bryoniae* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14): pp. 192-3.

Wild Hosts.

Cucurbitaceae.

Bryonopsis laciniosa (L.) Naud. (= *Bryonia laciniosa* L.)—Native bryony: November to May (Sth. Qld.) and May-August (Nth. Qld.). This is the more usual host for this species and within the periods mentioned the fruits are always heavily infested.

Melothria cunninghamii (F. Muell.) Benth.—a Native cucurbit: March. Mostly small flies are bred from this host.

Melothria maderaspatana (L.) Cogn. (= *Mukia scabrella* Arn.): April.

Passifloraceae.

Passiflora foetida L.—Stinking passion vine: June (Nth. Qld.)

Passiflora suberosa L.—Small-flowered passion vine: June-July (Nth. Qld.) (UQ).

Strumeta cacuminata Hering.

= *Chaetodacus dorsalis* Tryon, nec. Hendel, 1927. Proc. Roy. Soc. Qld. 38 (14): pp. 194-6.

Chaetodacus dorsalis var. *major* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14): p. 195.

Strumeta solani Perk. & May 1949. Univ. Qld. Dept. Biol. 2 (14): pp. 14-16.

This species, more commonly referred to as the Solanum fly, was for some time confused with *S. dorsalis* (Hendel), and most of the earlier host records for the species in Queensland are published under this name.

Considerable variation, in both size and colour, is found when a large series of specimens of *S. cacuminata* is examined. Individuals segregated according to the extent of black pigmentation on the thorax show an inverse correlation between size and area of pigmentation. Tryon's var. *major** is a large form exhibiting a minimum of black on the dorsum. At the other end of the scale are individuals almost wholly black on the mesonotum. Such variation is due entirely to food relationships during the larval state and the entire range of forms may be bred from a single collection of host fruits.

Commercial Hosts.

Solanaceae.

Capsicum frutescens L.—Chili: (T)—an unconfirmed record, suggesting that this is an occasional host.

* Tryon did not publish a description of this variety but merely referred to a type in the Queensland Museum (Reg. No. Q.M.D. 3126).

Capsicum frutescens L. var. *grossum* L. H. Bail.—Giant capsicum: (T).

Lycopersicon esculentum Mill.—Tomato: November—only a few specimens bred on one occasion.

Wild Hosts.

Solanaceae.

Solanum auriculatum Ait.—Wild tobacco: Summer and autumn (Sth. Qld.); winter, spring and early summer (Nth. Qld.). The fruits are generally heavily infested.

Solanum seaforthianum Andr.—Brazilian nightshade: February (Sth. Qld.) (DAS); August (Nth. Qld.) (UQ). Only a few specimens were bred in both instances. This host was collected on several occasions but these records were not confirmed. Large numbers of *S. tryoni* food forms were bred from this host (see p. 69).

Solanum verbascifolium L.—Wild tobacco. This host is heavily infested. The fruiting period is similar to that of *S. auriculatum*.

Hardy (1951) records this species from *Rhipogonum papuanum* C. T. White (fam. *Smilacaceae*), but states that it is a possible error (vide Hardy, 1951, p. 152).

Strumeta endiandrae Perk. & May.

Wild Hosts.

Annonaceae.

Cananga odorata (Lam.) Hook. f. & Thoms.—Ylang-ylang: May (UQ).

Lauraceae.

Beilschmiedia obtusifolia (F. Muell.) F. Muell.—Blush walnut: November (H). These fruits were collected on several occasions but this record was not confirmed.

Cryptocarya erythroxylon Maid. & Betche—Southern maple: July-September (Nth. Qld.) (P & M); November (Sth. Qld.) (UQ).

Endiandra discolor Benth.—Rose walnut: August-October. These fruits are generally heavily infested.

Endiandra sp: December. This undetermined species from Mount Tamborine (Sth. Qld.) was heavily infested.

Litsea leefeana (F. Muell.) Merr.—a Bollywood: November (H). The somewhat similarly coloured *Afrodacus mesoniger* May is the only species that has been bred from this host in southern Queensland. Hardy's record was established on the Atherton Tableland, Nth. Qld.

Strumeta fagraea (Tryon).

= *Chaetodacus fagraea* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14): pp. 188-90.

Wild Hosts.

Loganiaceae.

Fagraea cambageana Domin: June-September—the fruits are heavily infested.

Fagraea muelleri Benth.: June-October—also supports this species in large numbers.

Myrtaceae.

Eugenia sp. (near *suborbicularis* Benth.): September (H).

Strumeta fuscatus Perk. & May.

= *Dacus* (*Strumeta*) *laticaudus* Hardy 1950. Proc. Hawaii. Ent. Soc. 14 (1): pp. 87-9.

Wild Hosts.

Combretaceae.

Terminalia muelleri Benth.: August (UQ). Despite several collections of this host, this record has not been confirmed.

Euphorbiaceae.

Glochidion ferdinandii Muell. Arg.: August (UQ).

Sapotaceae.

Planchonella obovata (R. Br.) H. J. Lam: July-September. Most fruit is infested.

Strumeta halfordiae (Tryon).

= *Chaetodacus halfordiae* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14): pp. 190-1.

Chaetodacus gurneyi Perk. 1934. Proc. Roy. Soc. Qld. 45 (9): pp. 41-2.

This synonymy was established after a close check of type material and the examination of series of specimens bred from *Halfordia kendack* (Montr.) Guillaum. (= *H. drupifera* F. Muell.) from the type locality, and hosts of *S. gurneyi*. Tryon (1927) admits describing this species from teneral material and failed to note the brown colouration on the scutellum.

Many host records rightly belonging to this species have been ascribed in the past to *S. tryoni* (Frogg.). Superficially these two species are somewhat similar. Though *S. halfordiae* is relatively common in lure traps at certain times of the year and can be bred from several hosts, both cultivated and

wild, only one host, *H. kendack,* was recorded by Tryon (1927). No doubt many records for this species were included by this author among his host list for *S. tryoni* (Tryon, 1927, pp. 184-5). Four hosts in Tryon's list—*Acronychia laevis* Forst., *Ficus glomerata* Willd., *Planchonella australis* (R.Br.) Pierre (= *Sideroxylon australe* (R.Br.) F. M. Bail.) and *Rauwenhoffia leichhardtii* (F. Muell.) Diels (= *Melodorum leichhardtii* (F. Muell.) Benth.)—are usually infested by *S. halfordiae.*

This is one of the species that exhibits considerable variation within a series of specimens bred from the same host. Variation occurs in the size and shape of the facial spots, the extent of brown colouration on the scutellum, the intensity of markings on the mesonotum and abdominal tergites and the length of the lateral post sutural stripes. Some specimens tend towards the general characters for *S. kraussi* Hardy, and the possible relationship between these two species is discussed on page 56.

Commercial Hosts.

Rosaceae.

Eriobotrya japonica (Thunb.) Lindl.—Loquat: September—occurs quite commonly in this host in coastal areas.

Rutaceae.

Citrus paradisi Macf.—Grapefruit: Autumn. Appreciable numbers have been bred from this host in the Nambour-Palmwoods area.

Citrus reticulata Blanco—Mandarin: Spring—occasional specimens only.

Citrus sinensis Osbeck—Orange: Autumn. This host is attacked occasionally in coastal areas.

Fortunella japonica (Thunb.) Swingle—Kumquat: December. Occasional specimens may be recorded among large numbers of *S. tryoni.*

Ornamental Hosts.

Myrtaceae.

Eugenia uniflora L.—Brazilian cherry: December—occasional specimens among large numbers of *S. tryoni.*

Feijoa sellowiana Berg—Feijoa: February—occasional specimens among large numbers of *S. tryoni.*

Wild Hosts.

Annonaceae.

Rauwenhoffia leichhardtii (F. Muell.) Diels (= *Melodorum leichhardtii* (F. Muell.) Benth.): February-May—frequently bred in large numbers, with occasional *S. tryoni,* from this fruit.

Moraceae.

Ficus glomerata Willd.—a Cluster fig: May (P)—associated with *S. tryoni.*

Myrtaceae.

Eugenia corynantha F. Muell.—Sour cherry: October-December—usually in association with *S. tryoni.*

Rutaceae.

Acronychia laevis Forst.: April. Always associated with this host and the fruit may be heavily infested.

Halfordia kendack (Montr.) Guillaum. (= *Halfordia drupifera* F. Muell.)—Saffron heart: September.

Sapotaceae.

Niemeyera chartacea (F. M. Bail.) C. T. White (= *Lucuma chartacea* F. M. Bail.): December—may be heavily infested.

Planchonella australis (R. Br.) Pierre (= *Sideroxylon australe* (R. Br.) F. M. Bail.)—Black apple: November-December—commonly associated with this fruit.

Strumeta humeralis (Perk.).

= *Chaetodacus humeralis* Perk. 1934. Proc. Roy. Soc. Qld. 45 (9): pp. 42-3.

Dacus tryoni var. *neohumeralis* Hardy 1951. Pacif. Sci. 5 (2): pp. 169-70.

Though readily distinguished from *S. tryoni* (Frogg.) on colour characters, *S. humeralis* is closely related to this species in its host range, seasonal abundance and general morphological characters. The status of this fly is at present under investigation, but from the information available it would seem that it may well be a variety of *tryoni*, as suggested by Hardy (1951).

This fly may be bred in very large numbers from certain of its hosts and at times may be the only fly to emerge. It is more abundant in the northern areas of the State, where it may heavily infest guava (*Psidium guajava* L.) and species of *Citrus*. More usually, it occurs in association with *S. tryoni*, this being the dominant species.

Commercial Hosts.

Anacardiaceae.

Mangifera indica L.—Mango: Very occasional specimens are obtained among numbers of *S. tryoni.*

Moraceae.

Morus nigra L.—Black mulberry.

Rosaceae.

Eriobotrya japonica (Thunb.) Lindl.—Loquat: Spring—commonly associated with this fruit.

Malus sylvestris Mill.—Apple.

Prunus armeniaca L.—Apricot.

Prunus domestica L.—Plum.

Prunus persica (L.) Batsch—Peach.

Pyrus communis L.—Pear: Occasional specimens among large numbers of *S. tryoni* were bred during spring and summer months.

Rubiaceae.

Coffea arabica L.—Coffee.

Rutaceae.

Citrus sinensis Osbeck—Orange.

Citrus grandis Osbeck—Pomelo or shaddock.

Citrus limon Burm. f.—Lemon.

Citrus paradisi Macf.—Grapefruit.

Citrus reticulata Blanco—Mandarin.

Fortunella japonica (Thunb.) Swingle—Kumquat.

Most species of *Citrus* may be stung by this fly whenever fruit is approaching the ripe state. Lemons, other than the variety Meyer, are only attacked when the fruits have been allowed to ripen on the tree or are lying on the ground as ripened windfalls.

Solanaceae.

Cyphomandra betacea Sendt.—Tree tomato: This is the only species bred from these fruits.

Lycopersicon esculentum Mill.—Tomato: It occurs in association with *S. tryoni.*

Ornamental Hosts.

Anacardiaceae.

Spondias cytherea Sonn.—Vi apple or hog plum.

Myrtaceae.

Eugenia uniflora L.—Brazilian cherry: September-December.

Feijoa sellowiana Berg—Feijoa: February.

Both these hosts are commonly infested with occasional individuals among large numbers of *S. tryoni.*

Psidium cattleianum Sabine—Cherry guava.

Wild Hosts.

Capparidaceae.

Capparis lucida (DC.) R. Br. ex Benth.: January (H). Though several collections of this fruit were made, this record was not confirmed.

Combretaceae.

Terminalia melanocarpa F. Muell.: August—occasional specimens among large numbers of *S. tryoni.*

Lauraceae.

Cryptocarya erythroxylon Maid. & Betche—Southern maple: September (UQ).

Endiandra compressa C. T. White—Queensland greenheart: February (UQ).

Myrtaceae.

Psidium guajava L.—Guava. This host is commonly infested by *humeralis,* particularly in North Queensland.

Passifloraceae.

Passiflora alba Link & Otto—White passion fruit: February to May—common in this host.

Passiflora suberosa L.—Small-flowered passion vine: June and July (Nth. Qld.) (P)—frequently associated with this host.

Rutaceae.

Clausena brevistyla Oliv.: February (H).

Sapindaceae.

Ganophyllum falcatum Bl.: January (H).

Sapotaceae.

Niemeyera chartacea (F. M. Bail.) C. T. White (= *Lucuma chartacea* F. M. Bail.): December.

Planchonella obovata (R. Br.) H. J. Lam: September (UQ).

Solanaceae.

Solanum laciniatum Ait. (= *S. aviculare* auct. austr.)—Kangaroo apple: Late summer (DAS).

Solanum seaforthianum Andr.—Brazilian nightshade: April.

Further search should reveal many more hosts for this fly. The expanded list of hosts, no doubt, will include many already recorded for *S. tryoni.*

Strumeta kraussi Hardy.

This species resembles *S. halfordiae* in many respects and is only separated on colour differences and the length of the ovipositor. A comparison of the hosts of the two species suggests some relationship. However, the zones of distribution differ in that *S. halfordiae* has been found only in southern Queensland and *S. kraussi* in North Queensland.

Ornamental Hosts.

Apocynaceae.

Thevetia peruviana (Pers.) Schum.—Yellow oleander: February (H). This record has not been confirmed.

Myrtaceae.

Syzygium branderhorstii Lauterb.: January and February (H). Hardy (1951) recorded this host as *Eugenia branderhorstii*.

Wild Hosts.

Annonaceae.

Cananga odorata (Lam.) Hook. f. & Thoms.—Ylang-ylang: July (UQ).

Cunoniaceae.

Schizomeria whitei J. Mattf.—Northern white birch: January and February (H).

Icacinaceae.

Irvingbaileya australis (C. T. White) Howard: February (UQ).

Lauraceae.

Endiandra compressa C. T. White—Queensland greenheart: November and March (H).

Endiandra discolor Benth.—Rose walnut: August—occasional specimens among large numbers of *S. endiandrae*.

Endiandra palmerstonii (F. M. Bail.) White and Francis: April (DAS) and August (UQ).

Myrtaceae.

Acmena macrocarpa C. T. White: June and July—bred in very large numbers.

Eugenia australis Wendl. ex Link—Creek lilly pilly: August (UQ).

Eugenia cormiflora F. Muell.: July and December (H).

Eugenia luehmannii F. Muell.—Small-leaved water gum: January and February (H).

Eugenia suborbicularis Benth.: August (H).

Eugenia tierneyana F. Muell.: January and February (H).

Psidium guajava L.—Guava: March and June (H).

Rhodomyrtus macrocarpa Benth.—Finger cherry: November (H).

Rutaceae.

Acronychia acidula F. Muell.—Scrub lemon: June to August—not recorded in very large numbers.

Sapindaceae.

Arytera sp. (?): September (H).

Castanospora alphandii (F. Muell.) F. Muell.: December (H)—*S. tryoni* bred from the same fruits.

Thymelaeaceae.

Phaleria clerodendron (F. Muell.) F. Muell. ex Benth.: April (DAS).

Strumeta melas Perk. & May.

There seems little doubt that *melas* should be classed as, at most, a variety of *tryoni*. Laboratory studies are at present under way to establish this point. Whereas *humeralis* differs from *tryoni* in having a dark brown or black humeral callus and in the colour pattern as well as the intensity of colour on both the thorax and abdomen, *melas* differs only in the intensity of black colouration on the thorax and is possibly only a melanic form. In size it compares with fully developed specimens of *tryoni*. Its commercial host range follows that of both *tryoni* and *humeralis*, though it has been bred from only one indigenous host.

Commercial Hosts.

Rosaceae.

Eriobotrya japonica (Thunb.) Lindl.—Loquat.

Malus sylvestris Mill.—Apple.

Prunus domestica L.—Plum.

Pyrus communis L.—Pear.

Only occasional specimens among large numbers of *S. tryoni* were bred from these hosts.

Rutaceae.

Citrus paradisi Macf.—Grapefruit: Autumn—occasional specimens.

Fortunella japonica (Thunb.) Swingle—Kumquat: Occasional specimens were found.

Wild Hosts.

Myrtaceae.

Psidium guajava L.—Guava: March (Nth. Qld.)—a very occasional specimen among a large series of *S. tryoni* and *S. humeralis*.

Passiflora alba Link & Otto—White passion fruit: January and February —more commonly bred than *S. tryoni* from this host.

Strumeta musae (Tryon).

= *Chaetodacus musae* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14): pp. 197-9.

C. musae var. *dorso-picta* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14): p. 198.

Considerable variation may exist, among newly emerged flies, in the extent of black pigmentation on the mesonotum. Some specimens possess an extensive reddish-brown pattern on the dorsum interspersed with areas of black pigmentation similar to that described by Tryon for his variety *dorso-picta**. With age, the intensity and extent of black pigmentation increases. Field specimens of *musae* are almost wholly black on the mesonotum.

This fly is confined to regions north of Cardwell, North Queensland, where it is an important pest of cultivated bananas. Unlike *S. tryoni,* it may sting fruit in the green state. It has never been recorded in the banana-growing areas of southern Queensland.

Commercial Hosts.

Musaceae.

Musa nana Lour.—Mons Mari, Cavendish and other dwarf banana varieties: These fruits are infested from June to August and January and February.

Musa paradisiaca L. var. *sapientum* (L.) Kuntze—Sweet plantain banana: August (UQ).

Wild Hosts.

Musaceae.

Musa banksii F. Muell.—a Native banana: June to September and February and March. Very large numbers of flies may be bred from this host.

The following, concerning families other than Musaceae, were recorded by Hardy (1951) as hosts of this well known species. Only one or two specimens were bred in each instance. These records have not been confirmed and it is suggested that they are in error as they are not consistent with the normal behaviour of this species.

Commercial Host.

Caricaceae.

Carica papaya L.—Papaw: February (H).

Wild Hosts.

Capparidaceae.

Capparis lucida (DC.) R.Br. ex Benth.: January (H).

Myrtaceae.

Psidium guajava L.—Guava: April (H).

Strumeta mutabilis May.

Though relatively common in lure traps in southern Queensland during spring and early summer, no indigenous hosts have been located.

Commercial Host.

Rutaceae.

Fortunella japonica (Thunb.) Swingle—Kumquat: December. One specimen was bred among a large series of *S. tryoni.*

* Tryon (1927) described his variety *dorso-picta* in a footnote on p. 198.

Strumeta notatagena May.

This fly has been taken only in traps in the Cairns area.

Strumeta pallidus Perk. & May.

Atypical forms of this species are found among bred and field-trapped material. These food forms exhibit varying intensities of black markings on the thorax and abdomen, though never to a marked degree.

Wild Host.

Rubiaceae.

Nauclea orientalis L. (= *Sarcocephalus cordatus* Miq.)—Leichhardt tree or canary wood: March to May. Large populations breed in these fruits during the autumn months, though the occasional fruit produced during the spring may be infested.

Strumeta pulcher (Tryon).

= *Bactrocera pulcher* Tryon 1927. Proc. Roy. Soc. Qld. 45 (9): pp. 206-7.

Specimens of *S. pulcher* have been trapped in the Nambour-Palmwoods area, close to the type locality, but no host has been located in southern Queensland. Hardy (1951) records one specimen bred from the fruits of *Planchonella* sp. collected near Atherton, North Queensland, in September.

Strumeta recurrens Hering.

= *Strumeta manskii* Perk. & May 1949. Univ. Qld. Dept. Biol. 2 (14): pp. 3-5.

Though the types have not been compared, Hering's description of *recurrens* differs from *manskii* only in colour densities on thorax and abdomen. The characteristic wing markings and other distinguishing characters establish this synonymy.

Wild Host.

Loganiaceae.

Strychnos bancroftiana F. M. Bail.: July to November (Nth. Qld.).

Strumeta strigatus (Perk.).

= *Chaetodacus strigatus* Perk. 1934. Proc. Roy. Soc. Qld. 45 (9): pp. 43-4.

This species was described from trapped material. Frequently it has been recovered from traps in the Gayndah, Gatton and Stanthorpe districts but search has failed to reveal host fruits.

Strumeta tryoni (Frogg.).

= *Tephritis tryoni* Frogg. 1897. Agric. Gaz. N.S.W. 8: pp. 410-12.

Chaetodacus tryoni var. *musa* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14): pp. 187-8.

C. tryoni var. *juglandis* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14): p. 188.

C. tryoni var. *sarcocephali* Tryon 1927. Proc. Roy. Soc. Qld. 38 (14): p. 188.

The several varietal forms recognised by Tryon (1927) have been recovered among specimens bred from their type hosts. Laboratory studies of this and related material have demonstrated that *juglandis* and *sarcocephali* are merely forms of *tryoni* which develop following abnormal food supply during the larval state*. Both forms were recovered frequently among flies bred from hosts of *tryoni*, a wide range of food forms emerging from hosts considered unsuitable for normal larval development. The variety *juglandis* represents only one stage in the range of forms that may occur among a series of flies bred from Tryon's type host, walnut (*Juglans regia* L.). It is extremely variable and intergrades with *sarcocephali* towards one end of the scale and with *tryoni* at the other. Typical *tryoni*, however, are seldom bred from this host.

A series of specimens bred from walnut and exhibiting variation due to food deficiencies can be arranged according to the extent of black colouration on the mesonotum. As the extent of the black pattern increases, the mean size of individuals within each group decreases. The extreme is a small fly intensely marked with dark brown or black on the thorax as well as on the second abdominal tergite. The density of these markings increases with age. Such specimens conform to the markings of Tryon's variety *sarcocephali*.

It is significant that many other species show these food forms among both laboratory-bred and field-trapped material. In all instances, an intensification of colour in the subcutaneous layers in certain regions of the thorax and abdomen is associated with a general decrease in body measurement.

Tryon's var. *musa*, bred from cultivated dwarf bananas (*Musa nana* Lour.), does not conform to the pattern exhibited by the two forms already discussed. Still another type of variation is found in material bred from mango (*Mangifera indica* L.). In many respects these two forms are lighter in colour, larger and generally atypical of the normal *tryoni*. As Tryon (1927) states, however, in his account of the form *musa*, "their general facies" are "difficult to define in words." Though obviously representing food forms of the species, these have not necessarily arisen due to deficiencies in the food supply.

* See also footnote p. 41.

Considerable variation, generally of a minor character, is obvious when a large series of *tryoni* is examined critically. Though superficially similar, closer examination will reveal colour and size differences covering a wide range of forms. Among the many flies examined during these studies, two outstanding conditions were noted. Firstly, certain commercial hosts gave rise to exceptionally large specimens, all more or less uniform for general colour and an absence of black markings. Flies from both cultivated banana and mango fall within this group. Secondly, for many commercial hosts and a large proportion of the wild hosts recorded, "dark" forms were prevalent and the flies were, on the whole, much smaller than usual. Those individuals exhibiting the extreme in black pigmentation on the thorax were generally small and in most instances died soon after emergence. These, also, were among the last flies to emerge from the sample.

Commercial Hosts.

Anacardiaceae.

Anacardium occidentale L.—Cashew: (T).

Mangifera indica L.—Mango: This host gives rise to large specimens. There is a wide variation in susceptibility depending on both mango variety and locality. The least fibrous varieties are more subject to attack. Fruit will also be stung and develop larvae after it has fallen to the ground.

Annonaceae.

Annona reticulata L.—Bullock's-heart: (H).

Annona squamosa L.—Custard apple: This is not an important host but may be damaged in certain seasons.

Caricaceae.

Carica papaya L.—Papaw: This fruit will be attacked during summer months if allowed to ripen on the tree.

Ebenaceae.

Diospyros kaki L. f.—Persimmon: Though this fruit may be heavily stung when it ripens in late summer and early autumn, a large percentage of the "stings" fail to develop. The fruits, however, are spoilt for commercial purposes. Obviously the texture of the pericarp is unsuitable for larval development.

Juglandaceae.

Juglans regia L.—Walnut: As mentioned earlier, these fruits are readily attacked but give rise to small flies showing extreme variation in colour.

Lauraceae.

Persea gratissima Gaertn. f.—Avocado: April.

Moraceae.

Ficus carica L.—Fig: Infestation is not usual in this host. It can occur, however, should the receptacle split, particularly following wet weather. Flies seem unable to oviposit through the skin of the receptacle, though eggs may be placed directly into the orifice of ripe fruit.

Morus alba L.—White mulberry: (T).

Morus nigra L.—Black mulberry.

Mulberries are commonly infested though only one or two larvae may be located in each fruit. The greater part of larval development takes place after the fruit have fallen to the ground. Large specimens are bred from this host.

Musaceae.

Musa nana Lour.—Mons Mari and Cavendish bananas: Unlike *S. musae*, which may sting these fruit while still quite immature, *S. tryoni* will only oviposit in fruit allowed to colour on the bunch. Normal methods of harvesting prevent losses from the latter pest.

Oleaceae.

Olea europaea L.—Olive: (T). These fruits are not usually infested.

Oxalidaceae.

Averrhoa carambola L.—Carambola or five corner: These fruits are commonly infested.

Palmae.

Phoenix dactylifera L.—Date palm. These fruits are cultivated in inland areas where populations of *S. tryoni* are seldom large. Infestation may occur though it is never severe. Fully developed larvae may pupate within the fruit, suggesting that they are unable to escape through the tough skin. When the plant is grown as an ornamental in coastal districts, its fruit may become heavily infested.

Passifloraceae.

Passiflora edulis Sims—Passion fruit: Though maggot development is exceedingly rare in these fruits, considerable crop damage may occur due to extensive oviposition in newly formed fruits. Oviposition punctures, seen as oval, raised, calloused areas in the skin, cause premature fruit fall.

Passiflora quadrangularis L.—Granadilla: Fruits are frequently stung when approaching the mature state. Larval development proceeds normally.

Punicaceae.

Punica granatum L.—Pomegranate: Infestation is usually associated with fruit that have split when ripe.

Rosaceae.

Cydonia oblonga Mill. (= *C. vulgaris* Pers.)—Quince: These fruits are often heavily stung while still in a very immature state. Normal larval development is apparently restricted, and small flies exhibiting a considerable range of food forms are bred from this host.

Eriobotrya japonica (Thunb.) Lindl.—Loquat: These fruits are usually heavily infested.

Malus sylvestris Mill. (= *Pyrus malus* L.)—Apple.

Prunus armeniaca L.—Apricot.

Prunus avium L.—Cherry.

Prunus domestica L.—Plum.

Prunus persica (L.) Batsch—Peach.

Prunus persica (L.) Batsch var. *nectarina* (Ait.) Maxim.—Nectarine.

Pyrus communis L.—Pear.

The above pome and stone fruits are readily stung by *S. tryoni* and rarely escape damage in areas where fruit fly is active. Certain early-maturing varieties of apricot, cherry and peach may escape damage in districts where spring temperatures are sufficiently low to retard ovarian development among the overwintering fly population.

Rubiaceae.

Coffea arabica L.—Coffee: Occasional fruits may be stung.

Rutaceae.

Citrus sinensis Osbeck—Orange.

Citrus grandis Osbeck (= *C. decumana* L.)—Pomelo or shaddock.

Citrus limon Burm. f.—Lemon: Lemons, except the variety Meyer, which may be attacked while in the green or semi-ripe state, are never stung unless allowed to ripen fully on the tree. Fallen fruit that have ripened on the ground may be stung and the larvae will develop to maturity.

Citrus medica L.—Citron: This is not an important host and only an occasional ripened fruit is stung, giving rise to food forms.

Citrus paradisi Macf.—Grapefruit: This fruit is very subject to attack as it ripens in many districts when populations are large. However, it is not unusual, as with other species of *Citrus*, to find that larvae fail to hatch though egglaying may have been heavy. On dissection, it is found that a layer of corky tissue has been formed around each egglaying puncture. Also, the inroads of blue-green moulds (*Penicillium* spp.) following egglaying punctures will often destroy the hatched larvae.

Citrus reticulata Blanco—Mandarin.

Fortunella japonica (Thunb.) Swingle—Kumquat.

Solanaceae.

Capsicum frutescens L. var. *grossum* L. H. Bail.—Giant capsicum: Food forms may be associated with this host.

Lycopersicon esculentum Mill.—Tomato: These fruits are attacked readily during the summer months, particularly following periods of wet weather or if the fruits are allowed to ripen on the plant. Flies bred from this host are usually of a large size and food forms are rarely encountered.

Physalis peruviana L.—Cape gooseberry (DAS): Food forms are bred from this host.

Vitaceae.

Vitis labruscana L. H. Bail.—Isabella grape (probably is *V. labrusa* L. x *V. vinifera* L.).

Vitis vinifera L.—European varieties of cultivated grape and wine grapes.

Grapes are more usually stung in years of large fly populations when egglaying may be intensive. Though larvae do not always develop to maturity, the fruit may be lost from secondary causes. Form *sarcocephali* is found among bred material.

Ornamental Hosts.

Anacardiaceae.

Spondias cytherea Sonn.—Vi apple or hog plum.

Cactaceae.

Opuntia ficus-indica Mill.—Indian fig: (T).

Flacourtiaceae.

Dovyalis caffra (Harv. & Sond.) Warb. (= *Aberia caffra* Harv. & Sond.)—Kei apple.

Flacourtia jangomas (Lour.) Miq. (= *F. cataphracta* Roxb.): (T).

Myrtaceae.

Eugenia jambos L.: December (H).

Eugenia uniflora L.—Brazilian cherry.

Feijoa sellowiana Berg—Feijoa.

Psidium cattleianum Sabine—Cherry guava.

These last three myrtaceous hosts are usually heavily infested.

Rutaceae.

Aegle marmelos Correa—Bael fruit: (T).

Wild Hosts.

Anacardiaceae.

Pleiogynium cerasiferum (F. Muell.) Domin—Burdekin plum: December —not an important host.

Annonaceae.

Polyalthia nitidissima (Dun.) Benth.—Canary beech: March (H)

Polyalthia sp.: January (UQ).

Rauwenhoffia leichhardtii (F. Muell.) Diels. (= *Melodorum leichhardtii* (F. Muell.) Benth.): November to May. This host is more frequently infested by *S. halfordiae* (see p. 53).

Apocynaceae.

Alyxia ruscifolia R. Br.—a Chain-fruit: December. Only an occasional food form was bred from these fruits.

Carissa ovata R. Br.—Currant bush: February (UQ). Though fruits were collected on several occasions, this record was not confirmed.

Ochrosia elliptica Labill.: (T).

Capparidaceae.

Capparis lucida (DC.) R. Br. ex Benth.: February (H).

Capparis mitchellii Lindl.—a Native pomegranate: January (UQ).

Capparis nobilis (Endl.) F. Muell. ex Benth.—a Native pomegranate: (T).

Though fruits of these three species of *Capparis* were collected on several occasions, none of the records were confirmed. Apparently these are not important hosts.

Celastraceae.

Elaeodendron australe Vent.: (T).

Siphonodon australe Benth.—Ivorywood: January.

Combretaceae.

Terminalia catappa L.—Tropical almond: February (H).

Terminalia melanocarpa F. Muell.: August.

Terminalia muelleri Benth.: July to September.

Melanic food forms are commonly bred from these hosts.

Cunoniaceae.

Davidsonia pruriens F. Muell.—Davidsonian plum: (T). Several collections of fruits failed to confirm this record.

Schizomeria ovata D. Don—White birch: (T).

Ebenaceae.

Diospyros australis (R. Br.) F. M. Bail.: (T).

Euphorbiaceae.

Glochidion ferdinandii Muell. Arg.: August (UQ). Food forms have been recovered from this host.

Hemicyclia australasica Muell. Arg.—Grey boxwood or yellow tulip: December to February. A complete range of food forms has been bred from these fruits.

Lauraceae.

Beilschmiedia obtusifolia (F. Muell.) F. Muell.—Blush walnut: November (H).

Cryptocarya erythroxylon Maid. & Betche—Southern maple: September (UQ).

Endiandra compressa C. T. White—Queensland greenheart: (T).

Endiandra discolor Benth.—Rose walnut: October (UQ).

Endiandra sp. (indet.): December.

Meliaceae.

Aglaia sapindina (F. Muell.) Harms (=*Hearnia sapindina* F. Muell): November (H).

Owenia venosa F. Muell.—Crow's apple: December (UQ). These fruit are rarely attacked by this species.

Moraceae.

Cudrania javanensis Trécul.—Indian cockspur: January and February.

Ficus glomerata Willd.—a Cluster fig: May (T).

Ficus macrophylla Desf.—Moreton Bay fig: December—infested very occasionally.

Ficus watkinsiana F. M. Bail.: (T). Several collections of these fruits have been made but this record has not been confirmed. Tryon (1927, p. 184) questions his own record and suggests that it may be *F. stephanocarpa* Warb. However, fruits of that species have never yielded *S. tryoni*.

Myrtaceae.

Eugenia australis Wendl. ex Link—Creek lilly pilly: July (UQ).

Eugenia cormiflora F. Muell.: December (H).

Eugenia corynantha F. Muell.—Sour cherry: December.

Eugenia smithii Poir.—Lilly pilly: (T).

Eugenia suborbicularis Benth.: August (H).

Psidium guajava L.—Guava: Though food forms may be recovered from infested material, these are due to larval competition and not to the unsuitability of the host for larval development.

Rhodamnia sessiliflora Benth.: March (H).

Oleaceae.

Notelaea longifolia Vent.: (T).

Passifloraceae.

Passiflora alba Link & Otto—White passion fruit: February.

Passiflora aurantia Forst.: (T).

Rhamnaceae.

Dallachya vitiensis (Seem.) F. Muell.: January (H).

Zizyphus mauritiana Lam.—Chinee apple: July—not heavily infested and gives rise chiefly to food forms.

Rosaceae.

Rubus fruticosus L.—Blackberry: February and March. Large flies were bred from these fruits, which are an important host in some areas.

Rubiaceae.

Nauclea orientalis L. (=*Sarcocephalus cordatus* Miq.)—Leichhardt tree or canary wood: October and May (T). Form *sarcocephali* was first recovered from this host.

Rutaceae.

Eremocitrus glauca (Lindl.) Swingle (=*Atalantia glauca* (Lindl.) Hook. f.)—Lime bush: (T).

Sapindaceae.

Castanospora alphandii F. Muell.: December (H).

Ganophyllum falcatum Bl.: February (H).

Sapotaceae.

Amorphospermum antilogum F. Muell. (=*Lucuma amorphosperma* F. M. Bail.)—Brown pearwood: December (H).

Mimusops elengi L.: December (H).

Niemeyera chartacea (F. M. Bail.) C. T. White (=*Lucuma chartacea* F. M. Bail.): December.

Planchonella australis (R. Br.) Pierre (=*Sideroxylon australe* (R. Br.) F. M. Bail.)—Black apple: November and December.

Planchonella pohlmaniana (F. Muell.) Pierre ex Dubard (= *Sideroxylon pohlmanianum* (F. Muell.) F. M. Bail.)—Yellow boxwood: (T).

Most sapotaceous fruits are infested by more than one species of Dacinae, and *S. tryoni*, if present, is usually in relatively small numbers.

Smilacaceae.

Rhipogonum papuanum C. T. White: November (H). This is an unusual record for *S. tryoni* and was not confirmed.

Solanaceae.

Solanum auriculatum Ait.—Wild tobacco: November (H).

Solanum laciniatum Ait. (=*S. aviculare* auct. austr.)—Kangaroo apple: Summer.

Solanum seaforthianum Andr.—Brazilian nightshade: March and April —melanic food forms are usually bred from these fruits.

Vitaceae.

Cissus antarctica Vent.: May (UQ). These fruits have been collected on several occasions but this record was not confirmed. This is, no doubt, an unimportant host.

The following are considered doubtful records:—

Cucurbitaceae.

Bryonopsis laciniosa (L.) Naud. (=*Bryonia laciniosa* L.)—Native bryony: (T). Despite numerous collections of this host from all parts of the State, this record has not been confirmed. Such a host does not conform to the habits of *S. tryoni.*

Rutaceae.

Acronychia laevis Forst.: (T). This is an important host of *S. halfordiae* (see p. 54). More recent collectors have been unable to confirm Tryon's original record.

Sapindaceae.

Atalaya hemiglauca (F. Muell.) F. Muell. ex Benth.—Whitewood: (T). This tree produces winged fruits with a minimum of pericarp. It is debatable whether it could support fruit fly larvae. Perhaps this was recorded in error for *Atalantia glauca* (=*Eremocitrus glauca*).

ZEUGODACUS Hendel.

Zeugodacus atrisetosus Perk.

Wild Host.

Meliaceae.

Aglaia sapindina (F. Muell.) Harms (= *Hearnia sapindina* F. Muell.): July and August (P & M).

Zeugodacus synnephes (Hendel).

= *Dacus synnephes* Hendel 1913. Ent. Mitt., 2: 40.

Bactrocera caudatus Tryon, nec. Fabr., 1927.

Proc. Roy. Soc. Qld. 38 (14): 203-6.

Wild Host.

Cucurbitaceae.

Bryonopsis laciniosa (L.) Naud. (= *Bryonia laciniosa* L.)—Native bryony: April to July. This species is not abundant in this host.

SECTION 2.

Host—Fruit Fly List.

In the following list, the recorded hosts of species of the subfamily Dacinae occurring in Queensland are presented alphabetically under their respective botanical families. The fruit fly species known or reported to breed in each host plant are given. Where necessary, relevant remarks or comments on the authenticity or importance of the record are given in the final column.

Botanical Name.	Common Name.	Species Recorded.	Remarks.
ALANGIACEAE			
Alangium villosum (Bl.) Wangerin subsp. *tomentosum* (F. Muell.) Bloemb. var. *australe* Bloemb.	Muskwood ..	*Neozeugodacus aureus*	
ANACARDIACEAE			
Anacardium occidentale L...	Cashew ..	*Strumeta tryoni* ..	
Mangifera indica L. ..	Mango	*Strumeta tryoni* ..	
		Strumeta humeralis ..	Occasional specimens.
Pleiogynium cerasiferum (F. Muell.) Domin	Burdekin plum	*Strumeta tryoni* ..	Not usually infested.
Semecarpus australiensis Engl.	Tar tree ..	*Daculus murrayi* ..	
		Afrodacus jarvisi ..	Not confirmed. (See p. 43).
Spondias cytherea Sonn. ..	Vi apple ..	*Strumeta tryoni* ..	
		Strumeta humeralis	Occasional specimens.
ANNONACEAE			
Annona reticulata L. ..	Bullock's-heart	*Strumeta tryoni* ..	
Annona squamosa L. ..	Custard apple ..	*Strumeta tryoni* ..	Not usually infested.
Cananga odorata (Lam.) Hook. f. & Thoms.	Ylang-ylang ..	*Strumeta endiandrae*	
		Strumeta kraussi ..	
Polyalthia nitidissima (Dun.) Benth.	Canary beech ..	*Strumeta tryoni* ..	
Rauwenhoffia leichhardtii (F. Muell.) Diels		*Strumeta halfordiae* ..	Breeds in large numbers.
		Strumeta tryoni ..	Occasional specimens.
APOCYNACEAE			
Alyxia ruscifolia R. Br. ..	a Chain-fruit ..	*Strumeta tryoni* ..	Not usually infested.
Alyxia spicata R. Br. ..	a Chain-fruit ..	*Strumeta alyxiae* ..	
Carissa ovata R. Br. ..	Currant bush ..	*Strumeta tryoni* ..	Not confirmed. (See p. 66).
Ochrosia elliptica Labill. ..		*Strumeta tryoni* ..	
Thevetia peruviana (Pers.) Schum.	Yellow oleander	*Strumeta kraussi* ..	
BARRINGTONIACEAE			
Barringtonia calyptrata R. Br.	a Barringtonia..	*Strumeta barringtoniae*	
Planchonia careya (F. Muell.) R. Knuth	Cockatoo apple	*Afrodacus jarvisi* ..	Usually heavily infested.

Botanical Name.	Common Name.	Species Recorded.	Remarks.
CACTACEAE			
Opuntia ficus-indica Mill.	Indian fig	*Strumeta tryoni*	
CAPPARIDACEAE			
Capparis lucida (DC.) R. Br. ex Benth		*Diplodacus signatifer*	
		Strumeta tryoni	Not confirmed. (See p. 66).
		Strumeta humeralis	Not confirmed. (See p. 56).
		Strumeta musae	Doubtful record. (See p. 59).
Capparis mitchellii Lindl.	a Native pomegranate	*Strumeta tryoni*	Not confirmed. (See p. 66).
Capparis nobilis (Endl.) F. Muell. ex Benth.	a Native pomegranate	*Strumeta tryoni*	Not confirmed. (See p. 66).
CARICACEAE			
Carica papaya L.	Papaw	*Strumeta tryoni*	Ripe fruit stung.
		Austrodacus cucumis	Occasional host.
		Strumeta musae	Doubtful record. (See p. 59).
CELASTRACEAE			
Elaeodendron australe Vent.		*Strumeta tryoni*	
Siphonodon australe Benth.	Ivorywood	*Strumeta tryoni*	Not usually infested.
COMBRETACEAE			
Terminalia catappa L.	Tropical almond	*Strumeta tryoni*	
		Afrodacus jarvisi	
Terminalia melanocarpa F. Muell.		*Strumeta tryoni*	
		Strumeta humeralis	
Terminalia muelleri Benth.		*Strumeta tryoni*	
		Strumeta bilineata	Not confirmed. (See p. 49).
		Strumeta fuscatus	Not confirmed. (See p. 52).
CUCURBITACEAE			
Bryonopsis laciniosa (L.) Naud.	Native bryony	*Strumeta bryoniae*	Usually infested.
		Zeugodacus synnephes	Occasional specimens.
		Austrodacus cucumis	Chiefly North Queensland.
		Strumeta tryoni	Doubtful record. (See p. 69).
Cucumis melo L.	Rock melon	*Austrodacus cucumis*	
Cucumis sativus L.	Cucumber	*Austrodacus cucumis*	
Cucurbita pepo L.	Pumpkin	*Austrodacus cucumis*	
Cucurbita pepo L. var. *melo-pepo* Alef.	Squash	*Austrodacus cucumis*	
Cucurbita pepo L. var. *medullosa* Alef.	Marrow	*Austrodacus cucumis*	
Melothria cunninghamii (F. Muell.) Benth.	a Native cucurbit	*Strumeta bryoniae*	

Botanical Name.	Common Name.	Species Recorded.	Remarks.
Melothria maderaspatana (L.) Cogn.	a Native cucurbit	*Strumeta bryoniae* ..	
Momordica charantia L. ..	Chinese bitter cucumber	*Austrodacus cucumis*	
Sechium edule Sw.	Choko	*Austrodacus cucumis*	Oviposition in newly formed fruit only.
CUNONIACEAE			
Davidsonia pruriens F. Muell.	Davidsonian plum	*Strumeta tryoni* ..	Not confirmed. (See p. 66).
Schizomeria ovata D. Don ..	White birch ..	*Strumeta tryoni* ..	
Schizomeria whitei J. Mattf.	Northern white birch	*Strumeta kraussi* ..	
EBENACEAE			
Diospyros australis (R. Br.) F. M. Bail.		*Strumeta tryoni* ..	
Diospyros kaki L. f. ..	Persimmon ..	*Strumeta tryoni* ..	
		Afrodacus jarvisi ..	
EUPHORBIACEAE			
Glochidion ferdinandii Muell. Arg.		*Strumeta tryoni* ..	
		Strumeta fuscatus ..	
Glochidion harveyanum Domin		*Strumeta breviaculeus*	
		Austrodacus cucumis	Doubtful record. (See p. 46).
Hemicyclia australasica Muell. Arg.	Grey boxwood..	*Strumeta tryoni* ..	
		Strumeta humeralis ..	
FLACOURTIACEAE			
Dovyalis caffra (Harv. & Sond.) Warb.	Kei apple ..	*Strumeta tryoni* ..	
Flacourtia jangomas (Lour.) Miq.		*Strumeta tryoni* ..	
GUTTIFERAE			
Calophyllum inophyllum L.	Calophyllum ..	*Asiadacus calophylli*	Usually infested.
Garcinia kajewskii C. T. White	a Native mangosteen	*Heterodaculus visendus*	
Garcinia tinctoria (DC.) W. F. Wight		*Paratridacus expandens*	
ICACINACEAE			
Gomphandra australiana F. Muell.		*Melanodacus niger* ..	
Irvingbaileya australis (C. T. White) Howard		*Strumeta kraussi* ..	
JUGLANDACEAE			
Juglans regia L.	Walnut ..	*Strumeta tryoni* ..	
LAURACEAE			
Beilschmiedia obtusifolia (F. Muell.) F. Muell.	Blush walnut ..	*Strumeta tryoni* ..	
		Strumeta endiandrae	

Botanical Name.	Common Name.	Species Recorded.	Remarks.
Cryptocarya erythroxylon Maid. & Betche	Southern maple	*Strumeta tryoni* ..	
		Strumeta humeralis ..	
		Strumeta endiandrae	
Endiandra compressa C. T. White	Queensland greenheart	*Strumeta tryoni* ..	
		Strumeta humeralis	
		Strumeta kraussi ..	
Endiandra discolor Benth...	Rose walnut ..	*Strumeta endiandrae*	Usually infested.
		Strumeta tryoni ..	
		Strumeta kraussi ..	Occasional specimens.
Endiandra palmerstonii (F. M. Bail.) White & Francis	Queensland walnut	*Strumeta kraussi* ..	
Litsea leefeana (F. Muell.) Merr.	a Bollywood ..	*Afrodacus mesoniger*	
		Strumeta endiandrae	Doubtful record. (See p. 51).
Litsea reticulata (Meissn.) Benth.	a Bollywood ..	*Afrodacus mesoniger*	
Neolitsea involucrata (Lam.) Alston	Grey Bollywood	*Afrodacus mesoniger*	
Persea gratissima Gaertn. f.	Avocado ..	*Strumeta tryoni* ..	
LOGANIACEAE			
Fagraea cambageana Domin		*Strumeta fagraea* ..	Usually infested.
Fagraea muelleri Benth. ..		*Strumeta fagraea* ..	Usually infested.
Strychnos bancroftiana F. M. Bail.		*Strumeta recurrens* ..	Usually infested.
MELIACEAE			
Aglaia ferruginea White & Francis		*Neozeugodacus algaiae*	
Aglaia sapindina (F. Muell.) Harms		*Zeugodacus atrisetosus*	
		Neozeugodacus algaiae	
		Strumeta tryoni ..	
Owenia venosa F. Muell. ..	Crow's apple ..	*Strumeta tryoni* ..	Not usually infested.
MORACEAE			
Cudrania javanensis Trécul.	Indian cockspur	*Strumeta bancroftii* ..	Usually heavily infested.
		Strumeta tryoni ..	Occasional host.
Ficus carica L.	Fig	*Strumeta tryoni* ..	Overripe fruit stung.
		Strumeta melas ..	Occasional specimens.
Ficus glomerata Willd. ..	a Cluster fig ..	*Strumeta tryoni* ..	
		Strumeta halfordiae ..	
Ficus macrophylla Desf. ..	Moreton Bay fig	*Strumeta tryoni* ..	One record only.
Ficus watkinsiana F. M. Bail.	Green-leaved Moreton Bay fig	*Strumeta tryoni* ..	Doubtful record. (See p. 67).
Morus alba L.	White mulberry	*Strumeta tryoni* ..	
Morus nigra L.	Black mulberry	*Strumeta tryoni* ..	Usually infested.
		Strumeta humeralis ..	Usually infested.

Botanical Name.	Common Name.	Species Recorded.	Remarks.
MUSACEAE			
Musa banksii F. Muell. ..	a Native banana	*Strumeta musae* ..	Usually heavily infested.
Musa nana Lour.	Dwarf banana..	*Strumeta musae* ..	In North Queensland only.
		Strumeta tryoni ..	Ripe fruit stung.
Musa paradisiaca L. var. *sapientum* (L.) Kuntze	Sweet plantain banana	*Strumeta musae* ..	In North Queensland only.
MYRTACEAE			
Acmena macrocarpa C. T. White		*Strumeta kraussi* ..	
Eugenia australis Wendl. ex Link	Creek lilly pilly	*Strumeta tryoni* ..	
		Strumeta kraussi ..	
Eugenia cormiflora F. Muell.		*Strumeta kraussi* ..	
		Strumeta tryoni ..	
		Afrodacus jarvisi ..	
Eugenia corynantha F. Muell.	Sour cherry ..	*Strumeta halfordiae*..	
		Strumeta tryoni ..	
Eugenia jambos L.		*Strumeta tryoni* ..	
Eugenia luehmannii F. Muell.	Small-leaved water gum	*Strumeta kraussi* ..	
Eugenia smithii Poir. ..	Lilly pilly ..	*Strumeta tryoni* ..	
Eugenia suborbicularis Benth.		*Strumeta tryoni* ..	
		Strumeta kraussi ..	
		Afrodacus jarvisi ..	
Eugenia tierneyana F. Muell.		*Strumeta kraussi* ..	
Eugenia uniflora L. ..	Brazilian cherry	*Strumeta tryoni* ..	Usually infested.
		Strumeta humeralis..	Occasional specimens.
		Strumeta halfordiae..	Occasional specimens.
Feijoa sellowiana Berg ..	Feijoa	*Strumeta tryoni* ..	Usually infested.
		Strumeta humeralis..	Occasional specimens.
		Strumeta halfordiae..	Occasional specimens.
Psidium cattleianum Sabine	Cherry guava ..	*Strumeta tryoni* ..	Usually infested.
		Strumeta humeralis..	Occasional specimens.
Psidium guajava L. ..	Guava	*Strumeta tryoni* ..	Usually heavily infested.
		Strumeta humeralis..	Usually infested.
		Afrodacus jarvisi ..	Particularly in North Queensland.
		Strumeta melas ..	Occasional specimens.
		Strumeta kraussi ..	
		Strumeta breviaculeus	Not confirmed. (See p. 49).
Rhodamnia sessiliflora Benth.		*Strumeta tryoni* ..	
Rhodomyrtus macrocarpa Benth.	Finger cherry ..	*Strumeta kraussi* ..	
Syzygium branderhorstii Lauterb.		*Strumeta kraussi* ..	

Botanical Name.	Common Name.	Species Recorded.	Remarks.
OLEACEAE			
Notelaea longifolia Vent. ..		*Strumeta tryoni* ..	
Olea europaea L.	Olive	*Strumeta tryoni* ..	
Olea paniculata R. Br. ..	Native olive ..	*Melanodacus niger* ..	
ORCHIDACEAE			
Bulbophyllum baileyi F. Muell.		*Afrodacus jarvisi* ..	Males to flowers only. (See p. 44).
OXALIDACEAE			
Averrhoa carambola L. ..	Carambola or five corner	*Strumeta tryoni* ..	
PALMAE			
Phoenix dactylifera L. ..	Date palm ..	*Strumeta tryoni* ..	
PASSIFLORACEAE			
Passiflora alba Link & Otto	White passion fruit	*Strumeta tryoni* ..	Occasional host.
		Strumeta humeralis ..	Occasional host.
		Strumeta melas ..	Occasional host.
Passiflora aurantia Forst. ..		*Strumeta tryoni* ..	
Passiflora edulis Sims ..	Passion fruit ..	*Strumeta tryoni* ..	Larvae rarely develop.
Passiflora foetida L. ..	Stinking passion vine	*Strumeta bryoniae* ..	
Passiflora ligularis Juss. ..	Rock passion fruit	*Afrodacus jarvisi* ..	Males to flowers only. (See p. 44).
Passiflora quadrangularis L.	Granadilla ..	*Strumeta tryoni* ..	
Passiflora suberosa L. ..	Small-flowered passion vine	*Strumeta bryoniae* ..	
		Strumeta humeralis ..	
PUNICACEAE			
Punica granatum L. ..	Pomegranate ..	*Strumeta tryoni* ..	Split fruit stung.
		Afrodacus jarvisi ..	Occasional host.
RHAMNACEAE			
Dallachya vitiensis (Seem.) F. Muell.		*Strumeta tryoni* ..	
Zizyphus mauritiana Lam.	Chinee apple ..	*Strumeta tryoni* ..	
ROSACEAE			
Cydonia oblonga Mill. ..	Quince	*Strumeta tryoni* ..	
		Afrodacus jarvisi ..	One record only.
Eriobotrya japonica (Thunb.) Lindl.	Loquat ..	*Strumeta tryoni* ..	Usually infested.
		Strumeta humeralis ..	Occasional specimens.
		Strumeta halfordiae ..	Occasional specimens.
		Strumeta melas ..	Occasional specimens.
Malus sylvestris Mill. ..	Apple	*Strumeta tryoni* ..	
		Strumeta melas ..	
		Strumeta humeralis ..	
		Afrodacus jarvisi ..	Stung in cage tests only.

Botanical Name.	Common Name.	Species Recorded.	Remarks.
Prunus armeniaca L. ..	Apricot ..	*Strumeta tryoni* ..	Usually infested.
		Strumeta humeralis ..	Occasional specimen.
		Strumeta bilineata ..	One record.
Prunus avium L.	Cherry	*Strumeta tryoni* ..	
Prunus domestica L. ..	Plum	*Strumeta tryoni* ..	
		Strumeta humeralis ..	
		Strumeta melas ..	Very occasional specimens.
Prunus persica (L.) Batsch	Peach	*Strumeta tryoni* ..	
		Strumeta humeralis ..	
		Afrodacus jarvisi ..	
		Strumeta melas ..	Very occasional specimens.
Prunus persica (L.) Batsch var. *nectarina* (Ait.) Maxim.	Nectarine ..	*Strumeta tryoni* ..	
Pyrus communis L. ..	Pear	*Strumeta tryoni* ..	
		Strumeta humeralis ..	Occasional specimens.
		Afrodacus jarvisi ..	Occasional specimens.
		Strumeta melas ..	Occasional specimens.
Rubus fruticosus L. ..	Blackberry ..	*Strumeta tryoni* ..	
RUBIACEAE			
Coffea arabica L.	Coffee	*Strumeta tryoni* ..	
		Strumeta humeralis ..	
Nauclea orientalis L. ..	Leichhardt tree	*Strumeta pallidus* ..	Usually infested.
		Strumeta tryoni ..	
RUTACEAE			
Acronychia acidula F. Muell.	Scrub lemon ..	*Strumeta kraussi* ..	
Acronychia laevis Forst. ..		*Strumeta halfordiae* ..	
		Strumeta tryoni ..	Doubtful record. (See p. 69).
Aegle marmelos Correa ..	Bael fruit ..	*Strumeta tryoni* ..	
Citrus grandis Osbeck ..	Pomelo ..	*Strumeta tryoni* ..	
		Strumeta humeralis ..	
Citrus limon Burm. f. ..	Lemon	*Strumeta tryoni* ..	Ripe fruit stung. (See p. 64.)
		Strumeta humeralis ..	
Citrus medica L.	Citron	*Strumeta tryoni* ..	Not usually infested.
Citrus paradisi Macf. ..	Grapefruit ..	*Strumeta tryoni* ..	
		Strumeta humeralis ..	
		Strumeta halfordiae ..	Coastal regions.
		Strumeta melas ..	Occasional specimens.
Citrus reticulata Blanco ..	Mandarin ..	*Strumeta tryoni* ..	
		Strumeta humeralis ..	
		Strumeta halfordiae ..	Coastal region.
Citrus sinensis Osbeck ..	Orange ..	*Strumeta tryoni* ..	
		Strumeta humeralis ..	
		Strumeta halfordiae ..	Coastal regions.
		Callantra aequalis ..	Reported by Froggatt. (See p. 46).

Botanical Name.	Common Name.	Species Recorded.	Remarks.
Clausena brevistyla Oliv. ..		*Strumeta humeralis* ..	
Eremocitrus glauca (Lindl.) Swingle	Lime bush ..	*Strumeta tryoni* ..	
Fortunella japonica (Thunb.) Swingle	Kumquat ..	*Strumeta tryoni* ..	
		Strumeta humeralis ..	
		Strumeta halfordiae ..	Coastal areas.
		Strumeta melas ..	Occasional specimens.
		Strumeta mutabilis ..	One record.
Halfordia kendack (Montr.) Guillaum.	Saffron heart ..	*Strumeta halfordiae* ..	
SAPINDACEAE			
Arytera sp.		*Strumeta kraussi* ..	
Atalaya hemiglauca (F. Muell.) F. Muell. ex Benth.	Whitewood ..	*Strumeta tryoni* ..	Doubtful record. (See p. 69).
Castanospora alphandii (F. Muell.) F. Muell.		*Strumeta kraussi* ..	
		Strumeta tryoni ..	
Ganophyllum falcatum Bl...		*Strumeta tryoni* ..	
		Strumeta humeralis ..	
SAPOTACEAE			
Amorphospermum antilogum F. Muell.	Brown pearwood	*Strumeta tryoni* ..	
Mimusops elengi L. ..		*Strumeta tryoni* ..	
Niemeyera chartacea (F. M. Bail.) C. T. White		*Strumeta tryoni* ..	
		Strumeta humeralis ..	
		Strumeta halfordiae ..	
Planchonella australis (R. Br.) Pierre	Black apple ..	*Strumeta halfordiae* ..	
		Strumeta tryoni ..	
		Strumeta bilineata ..	
Planchonella obovata (R. Br.) H. J. Lam		*Strumeta fuscatus* ..	
		Strumeta bilineata ..	
		Strumeta humeralis ..	
Planchonella pohlmaniana (F. Muell.) Pierre ex Dubard	Yellow boxwood	*Strumeta bilineata* ..	
		Strumeta tryoni ..	
Planchonella sp.		*Strumeta pulcher* ..	One record only.
SMILACACEAE			
Rhipogonum papuanum C. T. White		*Strumeta tryoni* ..	Not confirmed. (See p. 68).
		Strumeta cacuminata	Doubtful record. (See p. 51).
SOLANACEAE			
Cyphomandra betacea Sendt.	Tree tomato ..	*Strumeta humeralis* ..	
Lycopersicon esculentum Mill.	Tomato ..	*Strumeta tryoni* ..	
		Strumeta humeralis ..	
		Austrodacus cucumis	Particularly in North Queensland.
		Strumeta cacuminata	One record only.

Botanical Name.	Common Name.	Species Recorded.	Remarks.
Physalis peruviana L. ..	Cape gooseberry	*Strumeta tryoni* ..	
Solanum auriculatum Ait...	Wild tobacco ..	*Strumeta cacuminata*	Usually infested.
		Strumeta tryoni ..	Occasional host.
Solanum laciniatum Ait. ..	Kangaroo apple	*Strumeta tryoni* ..	Occasional host.
		Strumeta humeralis ..	Occasional host.
Solanum seaforthianum Andr.	Brazilian nightshade	*Strumeta tryoni* ..	
		Strumeta humeralis ..	
		Strumeta cacuminata	Not confirmed. (See p. 51).
Solanum verbascifolium L...	Wild tobacco ..	*Strumeta cacuminata*	Always heavily infested.
SYMPLOCACEAE			
Symplocos thwaitesii F. Muell.		*Melanodacus niger* ..	
THYMELAEACEAE			
Phaleria clerodendron (F. Muell.) F. Muell. ex Benth.		*Strumeta kraussi* ..	
VITACEAE			
Cissus antarctica Vent. ..		*Strumeta tryoni* ..	Not confirmed. (See p. 69).
Vitis labruscana L. H. Bail.	Isabella grape ..	*Strumeta tryoni* ..	In certain years.
Vitis vinifera L.	Grape	*Strumeta tryoni* ..	In certain years.

Fig. 5.
Calophyllum inophyllum L., The Host of *Asiadacus calophylli* Perk. & May.
Cardwell, North Queensland.

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